Integrated Pest Management

for our environment • for our future

9th International IPM Symposium

Improving Health, Environment and Global Sustainability

March 19–22, 2018

Baltimore, MD

welcome

IPM: Improving Health, Environment and Global Sustainability

Welcome to the 9th international IPM Symposium!

Building on a tradition of 30 years, this event brings together a diverse group of IPM professionals from around the world to share their passion, collective wisdom, and success in finding IPM solutions, improving human health, and building environmental and global sustainability.

The field of IPM has never been so exciting, and crucial. Today's hottest research fields include global food security and the impact of climate change on food crops and vector-borne human disease.

The symposium offers us the rare opportunity to share the latest research, showcase our students as the scientists of the future, and learn from professional practitioners who apply science-based solutions and discover real-world emerging issues every day.

Our enthusiastic and energetic planning committees have worked to bring you a premier event including an opening keynote presentation by Dr. Dini M. Miller, Virginia Tech University, an internationally recognized expert in the area of bed bug and German cockroach IPM. There will be more than 40 concurrent sessions designed for practitioners, growers, educators, consultants, researchers, industry professionals, students, and employees of non-governmental organizations, and hot topic sessions including "Integrated Tick Management: Community-Wide Action to Address the Global Tick Problem." For the first time qualified sessions will come with Certified Crop Advisor credits in the IPM and professional development categories. In addition, the 2018 IPM Achievement Award winners will give presentations on their work.

More than 175 poster presentations this year include 45 student posters submitted for the IPM Inspiration Award.

As always attendees will have the opportunity to peruse exhibits from leading IPM suppliers, and enjoy field trips to see IPM in action in downtown Baltimore, and an optional trip to visit policymakers on Capitol Hill to educate them on IPM needs and benefits.

We would like to thank each of you for attending the IPM Symposium. Thanks to our sponsors, organizers, moderators, presenters, and participants for making the 9th International IPM Symposium a reality. You, as IPM leaders, have the vision, the knowledge, and dedication to forge a more sustainable future and a healthier world.

Enjoy!

9th International IPM Symposium Steering Committee Co-chairs
Dawn H. Gouge, University of Arizona
Lynnae Jess, North Central IPM Center
Eric Ritchie, McCain Foods
Thomas Green, IPM Institute of North America, Inc., *Emeritus Co-chair*

Integrated Pest Management

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contents

ILLINOIS

The 9th International IPM Symposium is coordinated by the Center for Innovation in Teaching & Learning.

ipmsymposium.org

sponsors and exhibitors

We thank our contributors and sponsors for their generous support of IPM and this symposium.

Mini-Symposia Sponsors

($7,500)

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US BIOLOGIC

Exhibitors

Exhibits are located in Maryland Ballroom DEF on the 5th level of the Renaissance Baltimore Harborplace Hotel. The continental breakfasts and breaks will be in this room.

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committees

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general information

Registration and Information Desk

The Registration Desk will be located outside the Maryland Ballroom, on the 5th floor of the Renaissance Baltimore Harborplace Hotel.

The desk will be open:

Monday, March 19, 10:00 AM–7:00 PM

Tuesday, March 20, 7:30 AM–4:30 PM

Wednesday, March 21, 7:30 AM–4:30 PM

Thursday, March 22, 7:30 AM–12:00 PM

Baltimore visitor information and a small gift shop can be found near the front desk at the ground level of the Renaissance Baltimore Harborplace Hotel.

Wireless Access

There is basic Wi-Fi in all meeting rooms at the Renaissance Baltimore Harborplace Hotel. The network is **Renaissance_Conf,** and the password is **IPM2018**. If you have trouble connecting, please go to to the Registration Desk for assistance.

Poster Sessions

The poster session will be held Wednesday, March 21, 4:30–6:30 PM in the Maryland Ballroom on the 5th floor of the Renaissance Baltimore Harborplace Hotel. While all posters will be displayed throughout the symposium, authors are asked to stand by their posters according to their poster number: odd numbers from 4:30–5:30 PM and even numbers from 5:30–6:30 PM.

Posters can be set up beginning at 10:00 AM on Tuesday. They should be in place by 4:30 PM on Wednesday. They can be removed after the poster session is over at 6:30 PM on Wednesday. They must be removed by 12:00 PM on Thursday.

If you would like to have your poster posted on the 2018 IPM Symposium web site, copy your poster as a .pdf file and send it to Michelle Marquart at mmarqua2@illinois.edu by May 15, 2018.

Poster Session Reception

All registered participants and their registered guests are invited to attend the reception, held during the poster session on Wednesday, March 21 from 4:30–6:30 PM in the Maryland Ballroom on the 5th level of the Renaissance Baltimore Harborplace Hotel. Hors d'oeuvres and a cash bar will be provided during the reception.

IPM Symposium 2018 App

Download the app by searching for "IPM Symposia."

Use the app to:

- Plan your schedule.
- Read presentation and poster abstracts.
- Evaluate sessions.
- Receive meeting alerts.
- Find people.
- Explore sponsors and exhibitors.
- Post photos.
- Search local places and maps.

The mobile app was sponsored by the Southern IPM Center in cooperation with the organizers of the symposium. Both Android and iOS versions are available from the Google Play Store and the Apple iTunes App Store.

Silent Auction

The Silent Auction will be held Wednesday, March 21 from 4:30–6:30 PM. Visit us in Maryland Ballroom DEF at Booth 7, alongside the exhibitors, and bid on auction items to help offset the cost for non-traditional IPM professionals attending the Symposium. At every Symposium, we are limited in our support due to the overall Symposium costs. All proceeds from the Silent Auction will be used to fund registration and travel support at future symposia.

Presenter Practice Room

If presenters need to preview their presentations, come to the Registration Desk during its hours of operation.

Media

The Registration Desk will serve as the media desk, located outside the Maryland Ballroom on the 5th floor of the Renaissance Baltimore Harborplace Hotel. Reporters and other members of the media should register at the Registration Desk.

Session Moderators

If you have technical difficulties during your session, please find the volunteer monitors with ribbons in the hallways or come to the Registration Desk.

Continuing Education Credits

Certified Crop Advisor (CCA) credits and Maryland Department of Agriculture pesticide recertification credits are available. Attendance sign-in sheets will be located at the Registration Desk.

Post-Symposium Evaluation

An online evaluation survey will be conducted after the symposium. An e-mail message will be sent to you with the details; we hope you will take a few minutes to complete the survey. Your feedback has significant impact on the Steering Committee's evaluation for this year's Symposium and planning decisions for the next.

Abstracts, Presentations, and Posters

Complete abstracts can be found at the Web site: ipmsymposium.org.

Presentations and posters will be added to the Web site after the symposium.

Congratulations to the 2018 International IPM Achievement Award recipients

International IPM Awards of Excellence

Dr. Dawn H. Gouge, University of Arizona (Practitioner)

Megacopta Working Group, based in the University of Georgia's College of Agriculture and Environmental Sciences Department (Team)

North Central Soybean Entomology Research and Extension Team (Team)

IPM of Late Blight and FFS Activity Program, piloted by the International Potato Center (Team)

International IPM Lifetime Achievement Awards

Dr. Peter B. Goodell, University of California Statewide IPM Program

Dr. Frank G. Zalom, Department of Entomology and Nematology, University of California, Davis

International IPM Awards of Recognition

Mr. Rachid El Aini, Omnium Agricole du Souss, Morocco (Practitioner)

European Grapevine Moth Team, California (Team)

PRISME Consortium, Quebec, Canada (Team)

Pest Management University, Florida (Team)

International IPM Awards for Graduate Students

Ms. Annie Rich, University of Georgia (Masters Student)

Mr. Zachary DeVries, North Carolina State University (Doctoral Student)

These recipients will be recognized during the Opening Session on Monday, March 19.

schedule at a glance

Monday, March 19

8:00–10:00 AM	National IPM Coordinator Meeting
10:00 AM–5:00 PM	Regional IPM Coordinator Meetings
10:00 AM–7:00 PM	Registration Open
1:00–4:30 PM	Field Trip A: IPM in Professional Sports Facility Management
1:00–4:30 PM	Field Trip B: Urban Growth - The Green Kind
1:00–4:30 PM	Field Trip C: Urban Housing IPM
1:00–5:00 PM	Sysco Supplier Meeting
5:00–7:00 PM	Opening Session with Keynote Dr. Dini Miller and Presentation of IPM Achievement Awards

Tuesday, March 20

Beverages available in Maryland Ballroom DEF from 7:00 AM–5:00 PM

7:30 AM–4:30 PM	Registration Open
7:00–8:30 AM	Continental Breakfast
8:30–10:00 AM	Mini-Symposia & Concurrent Sessions
10:15–11:45 AM	Mini-Symposia & Concurrent Sessions
11:45 AM–1:00 PM	Student Educational Luncheon—Invitation Only
11:45 AM–1:15 PM	Lunch on your own
1:15–2:45 PM	Mini-Symposia & Concurrent Sessions
3:00–4:30 PM	Mini-Symposia & Concurrent Sessions
5:00-6:00 PM	School IPM Meet & Greet

Wednesday, March 21

Beverages available in Maryland Ballroom DEF from 7:00 AM–5:00 PM

7:30 AM–4:30 PM	Registration Open
7:00–8:30 AM	Continental Breakfast
8:30–10:00 AM	Mini-Symposia & Concurrent Sessions
10:15–11:45 AM	Mini-Symposia & Concurrent Sessions
11:45 AM–1:15 PM	Lunch on your own
1:15–2:45 PM	Mini-Symposia & Concurrent Sessions
3:00–4:30 PM	Mini-Symposia & Concurrent Sessions
4:30–6:30 PM	Poster Session, Exhibits & Silent Auction

Thursday, March 22

Beverages available in Maryland Ballroom DEF from 7:00 AM–12:00 PM

7:30 AM–12:00 PM	Registration Open
7:00–8:30 AM	Continental Breakfast
8:30–10:00 AM	Concurrent Sessions
10:15–11:45 AM	Closing Plenary
12:00–8:30 PM	Optional Field Trip: Visit Capitol Hill to Educate Your Policy Makers about IPM!
12:00–5:00 PM	Optional Workshop: Evaluation of IPM Programs
1:00–3:00 PM	Organic and IPM Working Group Meeting

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interest tracks

See Daily Schedule for times and locations

Session # Session Name

Mini-Symposia

S1 Resistance Management—Sponsored by North Center IPM Center (organized by Susan Ratcliffe)

S9 Social and Economic Aspects of IPM (organized by George Frisvold) | *1 CCA CEU—Integrated Pest Management*

S21 Biopesticide Technology: Science and Challenges—Sponsored by Biological Products Industry Alliance (BPIA) (organized by Matt Baur) | *1 CCA CEU—Integrated Pest Management*

S32 Protection Pollinators—Sponsored by Syngenta (organized by Judy Wu-Smart) | *1 CCA CEU—Integrated Pest Management*

Communication and New Tools in Pest Management

S6 The Great Challenge: Communicating IPM to a Public Audience (organized by Michael Rozyne) | *1 CCA CEU—Professional Development*

S8 Communicating IPM to Diverse Audiences (organized by Mary Kay Malinoski, David L. Clement) | *1 CCA CEU—Professional Development*

S14 The New IPM: Where Is Crop Protection Taking Us? (organized by Susan Ratcliffe) | *1 CCA CEU—Integrated Pest Management*

S20 Novel Approaches to IPM Extension: Transferring Learning across Contexts (organized by Mary Halbleib) | *1 CCA CEU—Professional Development*

S26 Promoting IPM Techniques in State-sanctioned Study Materials for Pesticide Applicator Licensing: Best Practices from the Top Down (organized by Shannah Whithaus) | *1 CCA CEU—Integrated Pest Management*

S30 Tools and Processes for the Transition towards Lower-risk Pesticide Programs in IPM systems (organized by Paul Jepson, Katie Murray) | 1 CCA CEU—Integrated Pest Management

S37 Building Partnerships to Provide Pesticide Safety Education as Part of an IPM Program (organized by Kerry Richards) | *1 CCA CEU—Integrated Pest Management*

S43 Diagnostics, Biosecurity and IPM—Imagine the Future (organized by Martin Draper, Jim Stack) | *1 CCA CEU—Integrated Pest Management*

Cross-Disciplinary

S7 Weather Driven Epidemiological Forecasts for Efficient IPM Strategies (organized by Yu Takeuchi, Roger Magarey) | *1 CCA CEU—Integrated Pest Management*

S23 Nanotechnology and its Increasing Role in IPM (organized by Wade Elmer, Mathews Paret) | *1 CCA CEU—Integrated Pest Management*

S34 IPM Achievement Award Winners (organized by Janet Hurley) | *1 CCA CEU—Professional Development*

= Sessions applicable to crop consultants; food company field and sustainability leads including retailers, packers, shippers and processors; large national producer representatives; and producers

= Sessions applicable to urban, structural, and landscape IPM practitioners

Fruit, Nut, Specialty, Vegetable Crops

S2 How Can Microbial Control Agents Fit into IPM? Examples from the Field (organized by Stefan Jaronski) | *1 CCA CEU—Integrated Pest Management*

S10 Integrated Pest and Pollinator Management (IPPM): Integrating Pollinator Protection into Fruit and Nut IPM Programs (organized by David Biddinger, Ed Rajotte) | *1 CCA CEU—Integrated Pest Management*

S16 Bee-Friendly Reaches Major Retailers of Ornamentals: The Industry Adapts (organized by Sharon Selvaggio)

S22 *Drosophila suzukii* Management: What Have Researchers Been Spotting? (organized by Dalila Rendon, Cherre Bezerra DaSilva, Vaughn Walton) | *1 CCA CEU—Integrated Pest Management*

S29 Maintaining IPM Integrity with Invasive Insects (organized by David Owens, Norman Leppla) | *1 CCA CEU—Integrated Pest Management*

S33 The Spread and Management of the South American Tomato leafminer, *Tuta absoluta* (organized by Amer Fayad, Rangaswamy Muniappan) | *1 CCA CEU—Integrated Pest Management*

S39 IPM Packages for Tropical Crops: How the IPM Innovation Lab Helps Achieve Food Security in the Developing World (organized by Amer Fayad, Rangaswamy Muniappan) | *1 CCA CEU—Professional Development*

Practitioner

S15 Getting the Most out of Drones in the Field (organized by IPM Institute of North America & Eric Ritchie)

S31 How Growers Can Benefit from Weather Station Networks (organized by IPM Institute of North America) | *1 CCA CEU—Integrated Pest Management*

S38 What Growers and Crop Advisors Need to Know about Managing Brown Marmorated Stink Bug Based on the Latest Research (organized by IPM Institute of North America) | *1 CCA CEU—Integrated Pest Management*

S44 Effective Strategies for Minimizing Losses from Bagrada Bug (organized by IPM Institute of North America) | *1 CCA CEU—Integrated Pest Management*

Rangeland/Livestock/Pastures

S11 IPM on Rangeland: Accomplishments and Challenges (organized by Alexandre Latchininsky) | *1 CCA CEU—Integrated Pest Management*

S17 Biological Control—A Sustainable Approach in the IPM Toolkit (organized by Lisa Tewksbury, Donna Ellis) | *1 CCA CEU—Integrated Pest Management*

Row/Agronomic Crops/Field Crops

S4 Application of Trap and Cover Crops in Integrated Pest Management (organized by Gadi V.P. Reddy, Govinda Shrestha) | *1 CCA CEU—Integrated Pest Management*

S12 Climate Change and Pest Biology (organized by Fernando E. Vega, Lewis H. Ziska) | *1 CCA CEU—Integrated Pest Management*

S18 Managing the Former Allopatric *Helicoverpa zea* and *H. armigera* in the Americas: Experience and Challenges Going Forward (organized by Silvana Paula-Moraes, William D. Hutchison) | *1 CCA CEU—Integrated Pest Management*

S24 Knowledge and Tools to Combat Western Bean Cutworm: An Emergent and Adaptive Pest in North American Maize (organized by Thomas Hunt, Débora G. Montezano, Julie A. Peterson, Fred Springborn, Katharine A. Swoboda Bhattarai) | *1 CCA CEU—Integrated Pest Management*

S35 Organic Agriculture with Bio-intensive Pest Management as a Means to Adapt/Mitigate Climate Change (organized by Othumbamkatt Remadevi, Chandish R. Ballal)

Row/Agronomic Crops/Field Crops, *continued*

S41 Soybean Cyst Nematode Resistance Management (organized by George Bird) | *1 CCA CEU—Integrated Pest Management*

S46 Pesticide Use Determinants and Human Health (organized by Wei Zhang) | *1 CCA CEU—Integrated Pest Management*

Urban/Structural/Landscape etc.

S3 The Added Value of Amendments in Turfgrass IPM (organized by Joseph Roberts)

S5 Assessment-Based Pest Management (APM)—Why We Must Make Monitoring and Pest Assessment the Foundation of All Structural Pest Management! (organized by Dini Miller, Michael E. Scharf)

S13 Improving Health Outcomes Related to Asthma and Indoor Air Quality through Integrated Pest Management (organized by Michael Millican)

S19 Pest Management and Indoor Allergen Reduction in Low Income Housing (organized by Rachel Riley)

S25 School IPM: Sinking Ship or Soaring Success? A Discussion (organized by Shaku Nair)

S28 Integrated Tick Management: Community-Wide Action to Address the Global Tick Problem (organized by Frank Laufenberg, Tom Green)

S36 Moving IPM Indoors: Reaching Audiences Where They Are (organized by Susannah Reese)

S42 IPM in Housing: A Round Table to Discussion on Diversifying the Messenger (organized by Faith Oi, Janet Hurley, Dini Miller, Shanika Preston)

S45 Vector-Borne Diseases (organized by Stanton Cope)

S47 Partnerships to Strengthen the Role of Pest Exclusion in IPM (organized by Jody Gangloff-Kaufmann, Matthew Frye)

= Sessions applicable to crop consultants; food company field and sustainability leads including retailers, packers, shippers and processors; large national producer representatives; and producers

= Sessions applicable to urban, structural, and landscape IPM practitioners

daily schedule

Monday, March 19

6:15–7:45 AM	**Sysco Advisory Council Breakfast** | *Homeland*
8:00–10:00 AM	**National IPM Coordinator Meeting** | *Watertable AB*
10:00 AM–5:00 PM	**SERA-003 Meeting** | *Guilford*
10:00 AM–5:00 PM	**NCERA-222 Meeting** | *Fells Point*
10:00 AM–5:00 PM	**NEERA-1604 Meeting** | *Watertable C*
10:00 AM–5:00 PM	**IPM in the West Meeting** | *Federal Hill*
1:00–5:00 PM	**Sysco Supplier Meeting** | *Watertable AB*
1:00–4:30 PM	**Field Trip A:** "IPM in Professional Sports Facility Management" **Field Trip B:** "Urban Growth—The Green Kind" **Field Trip C:** "Urban Housing IPM" *Meet at registration desk outside Maryland ABC at 12:45 PM*
4:00–5:00 PM	**Beverages and snacks** | *Baltimore Foyer*
5:00–7:00 PM	**Opening Plenary Session** | *Baltimore Ballroom* **Keynote:** "How the Misapplication of "IPM (Integrated Pest Management)" in the Urban Environment Has Impacted German Cockroach Infestations—A Case for Assessment-Based Pest Management (APM)" | Dr. Dini M. Miller **Presentation of IPM Achievement Awards**

Tuesday, March 20

8:30–11:45 AM	**Concurrent Sessions**	
	8:30–11:45 AM	S1. Resistance Management (Mini-Symposium) | *Baltimore A*
	8:30–11:45 AM	S2. How Can Microbial Control Agents Fit into IPM? Examples from the Field | *Baltimore B*
	8:30–10:00 AM	S3. The Added Value of Amendments in Turfgrass IPM | *Guilford*
	8:30–11:45 AM	S4. Application of Trap and Cover Crops in Integrated Pest Management | *Homeland*
	8:30–11:45 AM	S5. Assessment-Based Pest Management (APM)—Why We Must Make Monitoring and Pest Assessment the Foundation of all Structural Pest Management! | *Fells Point*
	8:30–10:00 AM	S6. The Great Challenge: Communicating IPM to a Public Audience | *Federal Hill*
	10:15–11:45 AM	S7. Weather Driven Epidemiological Forecasts for Efficient IPM Strategies | *Guilford*
	10:15–11:45 AM	S8. Communicating IPM to Diverse Audiences | *Federal Hill*
11:45 AM–1:15 PM	**Today's IPM Experts Sharing Knowledge with Tomorrow's IPM Leaders—Student Educational Luncheon** (by invitation) | *Watertable AB*	

11:45 AM–1:15 PM **Lunch on your own**

1:15–4:30 PM **Concurrent Sessions**

1:15–4:30 PM S9. Social and Economic Aspects of IPM (Mini-Symposium) | *Baltimore A*

1:15–2:45 PM S10. Integrated Pest and Pollinator Management (IPPM): Integrating Pollinator Protection into Fruit and Nut IPM Programs | *Baltimore B*

1:15–2:45 PM S11. IPM on Rangeland: Accomplishments and Challenges | *Guilford*

1:15–2:45 PM S12. Climate Change and Pest Biology | *Homeland*

1:15–2:45 PM S13. Improving Health Outcomes Related to Asthma and Indoor Air Quality through Integrated Pest Management | *Fells Point*

1:15–2:45 PM S14. The New IPM: Where Is Crop Protection Taking Us? | *Federal Hill*

1:15–2:45 PM S15. Getting the Most out of Drones in the Field | *Watertable C*

3:00–4:30 PM S16. Bee-Friendly Reaches Major Retailers of Ornamentals: The Industry Adapts | *Baltimore B*

3:00–4:30 PM S17. Biological Control—A Sustainable Approach in the IPM Toolkit | *Guilford*

3:00–4:30 PM S18. Managing the Former Allopatric *Helicoverpa zea* and *H. armigera* in the Americas; Experience and Challenges Going Forward | *Homeland*

3:00–4:30 PM S19. Pest Management and Indoor Allergen Reduction in Low Income Housing | *Fells Point*

3:00–4:30 PM S20. Novel Approaches to IPM Extension: Transferring Learning Across Contexts | *Federal Hill*

5:00–6:00 PM **School IPM Meet & Greet** | *Watertable AB*

Everyone is invited to discuss school IPM.

Wednesday, March 21

8:30–11:45 AM **Concurrent Sessions**

8:30–11:45 AM S21. Biopesticide Technology: Science and Challenges (Mini-Symposium) | *Baltimore A*

8:30–10:00 AM S22. *Drosophila suzukii* Management: What Have Researchers Been Spotting? | *Baltimore B*

8:30–11:45 AM S23. Nanotechnology and its Increasing role in IPM | *Guilford*

8:30–11:45 AM S24. Knowledge and Tools to Combat Western Bean Cutworm: An Emergent and Adaptive Pest in North American Maize | *Homeland*

8:30–11:45 AM S25. School IPM: Sinking Ship or Soaring Success? A Discussion | *Fells Point*

8:30–10:00 AM S26. Promoting IPM Techniques in State-sanctioned Study Materials for Pesticide Applicator Licensing: Best Practices from the Top Down | *Federal Hill*

8:30–11:45 AM S28. Integrated Tick Management: Community-Wide Action to Address the Global Tick Problem | *Watertable AB*

10:15–11:45 AM S29. Maintaining IPM Integrity with Invasive Insects | *Baltimore B*

10:15-11:45 AM S30. Tools and Processes for the Transition towards Lower-risk Pesticide Programs in IPM Systems | *Federal Hill*

10:15-11:45 AM S31. How Growers Can Benefit from Weather Station Networks | *Watertable C*

11:45 AM–1:15 PM **Lunch on your own**

1:15–4:30 PM **Concurrent Sessions**

- 1:15–4:30 PM S32. Protecting Pollinators (Mini-Symposium) | *Baltimore A*
- 1:15–2:45 PM S33. The Spread and Management of the South American Tomato Leafminer, *Tuta absoluta* | *Baltimore B*
- 1:15–2:45 PM S34. IPM Achievement Award Winner Presentations | *Homeland*
- 1:15–2:45 PM S35. Organic Agriculture with Bio-intensive Pest Management as a Means to Adapt/Mitigate Climate Change | *Guilford*
- 1:15–2:45 PM S36. Moving IPM Indoors: Reaching Audiences Where They Are | *Fells Point*
- 1:15–2:45 PM S37. Building Partnerships to Provide Pesticide Safety Education as part of an IPM Program | *Federal Hill*
- 1:15–2:45 PM S38. What Growers and Crop Advisors Need to Know about Managing Brown Marmorated Stink Bug based on the Latest Research | *Watertable C*
- 1:15–4:30 PM S28. Integrated Tick Management: Community-Wide Action to Address the Global Tick Problem | *Watertable AB*
- 3:00–4:30 PM S39. IPM Packages for Tropical Crops: How the IPM Innovation Lab Helps Achieve Food Security in the Developing World | *Baltimore B*
- 3:00–4:30 PM S41. Soybean Cyst Nematode Resistance Management Coalition | *Homeland*
- 3:00–4:30 PM S42. IPM in Housing: A Round Table to Discussion on Diversifying the Messenger | *Fells Point*
- 3:00–4:30 PM S43. Diagnostics, Biosecurity and IPM—Imagine the Future | *Federal Hill*
- 3:00–4:30 PM S44. Effective Strategies for Minimizing Losses from Bagrada Bug | *Watertable C*

4:30–6:30 PM **Poster Session, Exhibits and Silent Auction** | *Maryland Ballroom*

Odd numbers present 4:30–5:30 PM

Even numbers present 5:30–6:30 PM

Thursday, March 22

8:30–10:00 AM **Concurrent Sessions**

- 8:30–10:00 AM S45. Vector-Borne Diseases | *Watertable Ballroom*
- 8:30–10:00 AM S46. Pesticide Use Determinants and Human Health | *Federal Hill*
- 8:30–10:00 AM S47. Partnerships to Strengthen the Role of Pest Exclusion in IPM | *Homeland*

10:15–11:45 AM **Closing Plenary Session** | *Baltimore Ballroom*

"Why IPM Makes a Difference: Lessons from a Lifetime" | Dr. George W. Norton

"The 'I' in IPM: Reflections on the International IPM Symposium and Evolution of the IPM Paradigm" | Dr. Frank G. Zalom

"Integrated Pest Management: Revitalizing and Reinvesting in a Proven Paradigm" | Dr. Peter B. Goodell

12:00–8:30 PM **Field Trip:** Visit Capitol Hill to Educate Your Policy Makers about IPM! | *Meet at registration desk outside Maryland ABC at 11:45 AM*

12:00–5:00 PM **Optional Workshop:** "Evaluation of IPM Programs" | *Fells Point*

1:00–3:00 PM **Organic and IPM Working Group Meeting** | *Guilford*

poster numbers and titles

The poster session is on Wednesday, March 21, 4:30–6:30 pm in the hotel. While all posters will be displayed throughout the symposium, authors are asked to stand by their posters according to their poster number: odd numbers from 4:30–5:30 pm and even numbers from 5:30–6:30 pm.

P1 Be part of the buzz! A live conversation about biocontrol at the 9th International IPM Symposium

P2 Hedgerow benefits align with food production and sustainability goals

P3 Soil solarization for integrated pest management in the Pacific Northwest (USA)

P4 Weather and climate driven models for IPM and invasive species management

P5 Grower valuation of the Network for Environment and Weather Applications

P6 The effects of mulching leaves in place on tick populations in lawns and parks

P7 Occurrence of egg parasitism in the exotic pest brown marmorated stink bug and the native beneficial spined soldier bug in three Maryland habitats

P8 Insights into winter survival strategies of North American hover flies (Syrphidae) and the implications for pollination and conservation biological control

P9 The impact of organic crop rotations and ecological weed management strategies on soil quality

P10 Evaluation of anaerobic soil disinfestation for ecofriendly weed management

P11 Reaching out to the big sky

P12 Make a difference? Make an IPM impact graphic!

P13 Regional IPM and IR-4 collaboration: Assessing pesticide compatibility in an IPM program

P14 DPH: Optimizing IPM for maximal impact

P15 Success of interdisciplinary professional doctoral programs

P16 Organic and IPM Working Group

P17 Vermont's Extension IPM program addresses diverse stakeholder needs

P18 Nebraska Extension Team: Protect beneficial insect ecosystems including pollinators

P19 Nebraska extension resistant/invasive issue team #IRPESTS

P20 Lessons learned and best practices for developing IPM online trainings

P21 Arkansas mini-grants—A county based ipm program

P22 North Dakota State University Extension pest management app

P23 Virtual plant clinics cultivate new ideas and collaborations

P24 Maryland invasive training and outreach programs

P25 Not being presented

P26 Worker Protection Standard for organic and small farms

P27 Pesticide Risk Tool: Reducing and reporting pesticide risks in IPM and sustainability initiatives

P28 Green Shield Certified and IPM STAR pest management certification programs

P29 The Sustainable Food Group introduces the Sustainability Standard

P30 Adoption of proactive resistance management practices to control *Bemisia tabaci* in Arizona and California

P31 Minimum risk pesticide active ingredient profiles

P32 Repeated temporal rotation from nontoxic bait to a cholecalciferol rodenticide enhances control of a wild house mouse population

P33 Entomotoxicant potential of *Croton penduliflorous* extract in the control of subterranean termites *Macrotermes subhyalinus*

P34 Protecting water resources with on-farm pesticide rinsate biobeds: A Canadian perspective

P35 The Prairie Pest Monitoring Network: A coordinated monitoring of field crop pests of the Canadian Prairies

P36 Illustrating the benefits of a strategic approach to reduced risk pest management: The case of foliar insect pests of prairie field crops in Canada

P37 Cereal Aphid Manager: A dynamic action threshold smartphone application for scouting cereal aphids

P38 Integrated management of wheat midge infestations in wheat crops of Western Canada

P39 Baseline regulation of key genes in the phenylpropanoid pathway and their role in defense against biotic stresses in Maize

P40 Antixenotic potential in pulses against the pea aphid *Acyrthosiphon pisum* (Harris)

P41 Susceptibility of small-seeded legumes to infestation by pea aphid *Acyrthosiphon pisum* (Harris)

P42 Integrated management of glyphosate-resistant horseweed [*Conyza canadensis* (L.) Cronq.] with tillage and herbicides in Nebraska soybean (*Glycine max* (L.) Merr.)

P43 Tools are available for integrated management of glyphosate-resistant common ragweed *(Ambrosia artemisiifolia* L.) in Nebraska soybean

P44 Diagnosis of diseases caused by *Diaporthe (Phomopsis)* species on soybean in the United States

P45 Comparison of a putative novel species of *Phytopythium* to other *Phytopythium* spp. for pathogenicity on soybean seed

P46 Not being presented

P47 Cropping intensity driven microclimate is influencing abundance of ground foraging predators in coffee farmlands

P48 Biology-based strategies for integrated management of *Rhizoctonia solani* in soybean fields

P49 The effect of fungicide application methods on foliar diseases, seed quality, and yield protection in soybean

P50 A meta-analysis and economic evaluation of soil and seed applied insecticide use in Indiana maize

P51 Soil insecticide and insecticidal seed treatment impacts on timing of northern corn rootworm beetle emergence from *Bt* corn

P52 Co-inoculation of *Burkholderia ambifara* C628 and *Bacillus simplex* R180 reduced Fusarium root rot disease in corn

P53 Developing a sequential sampling protocol for scouting sugarcane aphid, *Melanaphis sacchari* Zehntner, in sorghum

P54 Development of a prediction model to improve disease management in sunflower (*Helianthus annuus*)

P55 Dispersal of wheat curl mite from virus infected winter wheat

P56 Overwintering potential of *Puccina striiformis* f.sp. *tritici* in North Dakota, USA

P57 Detecting sugarcane aphid (*Melanaphis sacchari*) infestation in grain sorghum (Sorghum bicolor) using leaf spectral response

P58 Risk assessment of *pea seed-borne mosaic virus* (PSbMV) infecting field pea

P59 Fungicide treatments and wheat cultivar resistance: Two key strategies to effectively manage Fusarium Head Blight and Deoxynivalenol in southeastern Nebraska

P60 Rolled rye for weed suppression in black bean and soybean

P61 Adapting established IPM strategies to emerging pests: A tale of two stem borers in sugarcane

P62 Predators associated with sugarcane aphids and their impact on aphid suppression in sorghum in High Plains

P63 Comparing patterns of injury associated with potato leafhopper (Family: Cicadellidae) feeding across different alfalfa (*Medicago sativa*) cropping systems

P64 The status of western bean cutworm, *Striacosta Albicosta* (Smith), in New York State

P65 *Trichogramma ostriniae* takes on a new challenge: Western bean cutworm, an invasive pest in New York

P66 Automated monitoring traps for detection of western bean cutworm (*Striacosta albicosta*)

P67 Improving degree-day models for the flight phenology of western bean cutworm (Lepidoptera: Noctuidae)

P68 What is going on with the western bean cutworm on corn in Mexico?

P69 Integrated pest management and the role of spiders within Nebraska agroecosystems

P70 Screening of entomopathogenic fungi from West Central Nebraska against key pests of corn

P71 Nebraska growers' and crop consultants' knowledge and implementation of IPM of western bean cutworm

P72 Dispersal and avoidance behavior of western bean cutworm when exposed to *Bt* maize

P73 Characterizing larval movement of western bean cutworm in field maize

P74 Western bean cutworm feeding damage on *Bt* hybrids and implications for economic injury levels

P75 Flight of the western bean cutworm: population patterns of a noctuid pest over the past 30 years

P76 Differences in midgut gene expression between *Bt* exposed and unexposed Western bean cutworm

P77 Landscape-level effects among western bean cutworm developing on Cry1Fa & Vip3A corn in block and blended refuge plants

P78 Survey of bees and syrphid flies associated with flowering soybean in the midwestern United States

P79 Economics of *Lygus hesperus* management in Texas High Plains cotton

P80 Evaluation of efficacy of PB ropes in different ecological zones of Punjab, Pakistan

P81 Multi-crop analysis to study the impact of weather parameters on population of beneficial insects in district Sahiwal in Pakistan

P82 The efficacy of field-collected fungal pathogen against green stinkbug in the Maryland

P83 The use of native entomopathogens in integrated management of granary weevil *Sitophilus granarius* (L.) (Coleoptera: Curculionidae)

P84 Adding risk associated with weed management to a decision support system for peanut

P85 Extension of information to farmers from research in Ghana designed to mitigate aflatoxin contamination in peanut

P86 Parasitism of the invasive brown marmorated stink bug by a native tachinid fly

P87 Estimating the trapping area of the brown marmorated stink bug pheromone

P88 An IPM answer to grape rootworm, a reemerging vineyard pest

P89 The tale of two nepoviruses in Washington state vineyards

P90 Field-level fungicide exposure to honey bees (*Apis mellifera*) during orchard bloom in Michigan

P91 Straw mulching enhances productivity of virus-infected passion fruit in Uganda

P92 Right to the core: How Eco Apple® successfully reduced pesticide risk in northeast apple production

P93 Improving integrated pest management of leaffooted bug on almond and pistachio in the San Joaquin Valley

P94 Susceptibility of peaches, plums and cherries to spotted wing Drosophila in western New York

P95 Effect of plant extract *Ruta graveolens* against the date scale, *Parlatoria blanchardi* Targ., (Homoptera, Diaspididae) at Biskra oasis, Algeria

P96 Horizontal transfer of reduced-risk pesticides between oriental fruit fly *Bactrocera dorsalis* (Hendal)

P97 Management of *Tetranychus urticae* on strawberries using UV-C irradiation

P98 Invasive honeysuckle increases populations of the invasive vinegar fly, spotted wing Drosophila

P99 Seasonal activity of *Drosophila suzukii* Matsumura (Diptera: Drosophilidae), in North Dakota fruits

P100 Pest management on new cranberry plantings: Horticultural, regulatory, and economic drivers

P101 Monitoring spotted wing Drosophila through a statewide network in Ohio

P102 Testing novel attractants for *Drosophila suzukii*

P103 Integrated Pest and Pollinator Management: Investigating impacts of different pesticide programs on pollinator communities in commercial orchards

P104 Current distribution of the samurai wasp, *Trissolcus japonicus*, in North America

P105 Integrating cultural, behavioral, and chemical strategies to improve organic management of spotted wing drosophila

P106 Not being presented

P107 Integrated pest management of longan in Vietnam

P108 Ukiah High School Cockroach Project: IPM is a community effort

P109 Site specific management of nuisance geese on school properties: A case study from New York State

P110 Recognizing excellence in school integrated pest management

P111 Stop School Pests online integrated pest management training courses for school employees

P112 The effect of IPM outreach to schools via webinars

P113 Engaging school nurses to promote IPM

P114 City-wide invasive formosan termite monitoring project in Jacksonville, Florida

P115 Evaluation and modeling of TickBot: A tick-killing robot

P116 The Public Tick IPM Working Group enhances tick-borne disease stakeholder collaboration

P117 New tools in the vector management IPM toolbox

P118 Integrated pest management of mosquitoes: A case study of West Nile virus in California

P119 Cost-benefit analysis of total release foggers (TRFs)

P120 Impacts of promoting Integrated Pest Management (IPM) in home gardens and landscapes through the Vermont Extension Master Gardener Helpline

P121 Integrated pest management programming for community gardeners

P122 IPM education and outreach to urban and community audiences in California

P123 Urban gardens as a platform for experiential learning: Pollinator conservation, citizen science, and sustainability

P124 An IPM approach for the control of the common bed bug, *Cimex lectularius* L.

P125 Making the connection: IPM, in-home childcare, and asthma in Chicago's most at risk neighborhoods

P126 Entireleaf morningglory in paddy field's levee invades paddy field

P127 An innovative IPM solution for management of the invasive aquatic weed hydrilla

P128 Interactivity among fungi, select *Pinus*-associated insects and the Pinewood nematode in Louisiana

P129 An integrated management approach to controlling invasive sea lamprey in the Great Lakes

P130 Weeds as source of inoculum of *Diaporthe gulyae*, the causal agent of Phomopsis stem canker of sunflower

P131 Understanding the population dynamics of arthropod pollinators and their host preferences at the UMES campus

P132 Connecticut Integrated Pest Management Program

P133 Ecological IPM: Master Gardeners learning sustainable ways to manage insects in landscapes and gardens

P134 Recently established invasive pests on California ficus trees: Identification, impact, and management

P135 Novel SAR biopesticide LifeGard® bolsters resistance management toolbox

P136 Feed 'em and weep? Fertilizer effects on aphid population growth and biocontrol in greenhouse crops

P137 Control of *Phytophthora* root rot disease of hydrangea using biorational products and fungicides

P138 Management of Cercospora leaf spot of hydrangea using biorational products and fungicides

P139 Augmentative biological control of twospotted spider mite on hops in the midwest

P140 Creating a buzz for IPM in turf care using innovative community engagement

P141 Partnering with industry to deliver IPM continuing education to Florida's turfgrass professionals

P142 Detection of *Pythium* spp. in golf course irrigation systems

P143 Incorporating organic amendments to enhance control of dollar spot on bentgrass fairways

P144 Fungal communities infecting creeping bentgrass continuously change during the first six months

P145 Use of unmanned drones in Maryland nurseries as part of our IPM outreach

P146 Field trials to evaluate low risk pesticides for Japanese Beetles, *Popillia Japonica*, in nurseries

P147 New resources on thrips IPM in greenhouse production

P148 Optimizing irrigation management can reduce pesticide loss in nursery production

P149 Developing and implementing effective integrated pest management strategies for specialty crop growers in north Florida

P150 Use of multiple natural enemies to manage whiteflies on poinsettias

P151 Population dynamics and control of the crapemyrtle bark scale

P152 Control effect based on yellow-sticky-board against *Bemisia tabaci*

P153 Repetitive overseeding of athletic fields for organic weed management

P154 Managing virus diseases in vegetable and legume crops in Bangladesh, Cambodia, and Nepal

P155 Using multiple plant biostimulants in vegetable systems can increase yields and fruit quality, but not consistently

P156 Antagonistic potential of *Bacillus amyloliquefaciens* against major tropical vegetable pathogens

P157 Potato Sustainability Initiative: Continuous improvement in sustainable potato production

P158 An IPM approach to reduce wireworm damage in potatoes

P159 Buffering of soil microclimate through soil amendments and mulching has potential in management of insect-vectored virus diseases of tomato

P160 Genome sequencing and development of SNP genotyping assay for identification of *Tuta absoluta*

P161 Sweet corn pest population trends over 10 years in Maine

P162 Sweet Corn Scout—A new mobile application to help growers identify and scout for sweet corn pests

P163 Evaluation of alternative weed control methods for horticultural crops

P164 Not being presented

P165 Successful adoption of action threshold-based insecticide programs for thrips management in onion

P166 Making rational pest management decisions for organic production of *amaranthus* in North Carolina

P167 Aphid tower trapping results in Maine

P168 Promoting sustainable, biologically-based pest management systems for improved vegetable production in high tunnels

P169 Developing an attract and kill approach for harlequin bug, *Murgantia histrionica* (Hemiptera: Pentatomidae)

P170 Capacity building in small farm IPM at Alcorn State University

P171 Living mulch as a tool for integrated weed management in organic vegetables

P172 Evaluation of host preference of brown marmorated stink bug, *Halyomorpha halys*, on bell peppers

P173 Effect of *trichoderma* species on emergence indices, infection incidence and growth performance of sweet pepper

P174 Resistance of genetically-diverse soybean varieties to insect pests in the eastern shore of Maryland

P175 Pests: An unwanted side effect of tropical storms

P176 Alternative avoidance method of insecticide resistance using egg parasitoid to block rotation, periphery zone treatment

plenary sessions

Monday, March 19

5:00 | *Baltimore Ballroom*

Welcome from the Symposium Committees, Eric Ritchie, Co-Chair, Symposium Steering Committee, eric.ritchie@mccain.com, McCain Foods, Florenceville, NB, Canada

Welcome to Baltimore, Mayor Catherine Pugh, Baltimore, MD

Welcome to University of Maryland, Dr. Darren Jarboe, Agriculture Program Director, University of Maryland Extension, College of Agriculture and Natural Resources, University of Maryland, College Park, MD

Introduction of Dr. Miller, Lynn Braband, lab45@cornell.edu, NYS IPM Program of Cornell University, Rochester, NY

How the Misapplication of "IPM (Integrated Pest Management)" in the Urban Environment Has Impacted German Cockroach Infestations—A Case for Assessment-Based Pest Management (APM), Dr. Dini M. Miller, dinim@vt.edu, Virginia Tech University, Blacksburg, VA

The concept of Integrated Pest Management (IPM) originated in agriculture as a way to economically reduce crop damage caused by insect pests. Producers could regularly sample their crops for pests and based on that sampling, determine the potential for economic injury to their crop. If pest levels were below the economic injury level (EIL), and crop damage would be inconsequential, there was no need for pesticide application. The term "Integrated pest management" has more recently been applied to pest control in the urban environment. However, most lay-people have no understanding that IPM is a decision process. Thus, the purchasers of Urban IPM (apartment owners, procurement officers and home owners) do not know what they are supposed to get for their money. Many apartment managers or procurement officers think that IPM is a low-toxicity or non-toxic (to humans) method of killing pests that may not involve insecticides at all. The idea that IPM is a series of steps based on assessing (monitoring) the pest population, has been completely lost. Even in the pest management industry, where professionals frequently use the term IPM to represent the industry's "best practices," *assessing* the pest problem (where, and how many) prior to treatment is rarely done. US HUD strongly encourages their housing managers to request contractors to use integrated pest management in their facilities. However, because the managers do not realize that IPM is based in monitoring, they neither require nor expect any pest assessment or efficacy data. This presentation will discuss how misapplied "IPM" has led to HUD housing facilities in Virginia and North Carolina being overrun with German cockroach populations. In addition, we will discuss how changing the term IPM to Assessment-Based Pest Management (APM) might aid in establishing pest monitoring as the foundation of the urban pest management process.

Presentation of IPM Achievement Awards

Janet A. Hurley, Co-Chair, Symposium Awards Committee jahurley@ag.tamu.edu, Department of Entomology, Texas A&M AgriLife Extension, Dallas, TX, and committee members

International IPM Awards of Excellence

- Dr. Dawn H. Gouge, University of Arizona (Practitioner)
- Megacopta Working Group, based in the University of Georgia's College of Agriculture and Environmental Sciences Department (Team)
- North Central Soybean Entomology Research and Extension Team (Team)
- IPM of Late Blight and FFS Activity Program, piloted by the International Potato Center (Team)

International IPM Lifetime Achievement Awards

- Dr. Peter B. Goodell, University of California Statewide IPM Program
- Dr. Frank G. Zalom, Department of Entomology and Nematology, University of California, Davis

International IPM Awards of Recognition

- Mr. Rachid El Aini, Omnium Agricole du Souss, Morocco (Practitioner)
- European Grapevine Moth Team, California (Team)
- PRISME Consortium, Quebec, Canada (Team)
- Pest Management University, Florida (Team)

International IPM Awards for Graduate Students

- Ms. Annie Rich, University of Georgia (Masters Student)
- Mr. Zachary DeVries, North Carolina State University (Doctoral Student)

Closing Remarks

Lynn Braband, lab45@cornell.edu, NYS IPM Program of Cornell University, Rochester, NY

Thursday, March 22

10:15 | *Baltimore Ballroom*

Presiding: Lynnae Jess, Co-Chair, Symposium Steering Committee, jess@msu.edu, North Central IPM Center, Department of Entomology, Michigan State University, East Lansing, MI

Recognition of Winners of Student Poster Competition, Symposium Poster Committee

Why IPM Makes a Difference: Lessons from a Lifetime, Dr. George W. Norton, 2015 Lifetime Achievement Awardee, gnorton@vt.edu, Department of Agricultural and Applied Economics, Virginia Polytechnic Institute and State University, Blacksburg, VA

Pest problems destroy livelihoods and lives around the world. IPM can make a difference. But how much? And what helps an IPM program succeed? This talk provides a personal perspective on these questions, with examples and lessons from the United States and developing countries. The examples highlight the need for interdisciplinary research and extension, team approaches, and keeping an eye on impact. They illustrate positive, real effects of IPM on people's lives—and why a career in IPM can be rewarding as well as fun.

The 'I' in IPM: Reflections on the International IPM Symposium and Evolution of the IPM Paradigm, Dr. Frank G. Zalom, 2018 Lifetime Achievement Awardee, fgzalom@ucdavis.edu, Department of Entomology and Nematology, University of California, Davis, CA

Conceived by a group of USDA and University Agricultural Experiment Station administrators, known as the National IPM Coordinating Committee, and organized by a planning committee of university-based IPM researchers, a National Integrated Pest Management Symposium/Workshop was held in Las Vegas, NV in April 1989. The meeting's theme was 'Targeting Research for IPM Implementation'. Over 500 people attended that meeting, and it documented the interest in convening the IPM community periodically to assess the status of IPM knowledge and use as well as opportunities and challenges moving forward. Reflections on themes and outcomes of subsequent IPM Symposia reflect the evolution of the paradigm over the last 3 decades and provide, perhaps, a window into IPM's future.

Integrated Pest Management: Revitalizing and Reinvesting in a Proven Paradigm, Dr. Peter B. Goodell, 2018 Lifetime Achievement Awardee, pbgoodell@ucanr.edu, University of California Statewide IPM Program, Kearney Agricultural Research and Extension Center, Parlier, CA

Integrated Pest Management (IPM) is a familiar yet often misunderstood approach to managing pests that afflict us, damage our structures and public spaces, and create loss in our food and fiber systems. But over the past 50 years, IPM has been redefined scores of times; shifting, tweaking, and modifying the concept to fit the political and cultural milieu of the day. Therefore, IPM progress cannot be simply be measured by use or non-use of practices but rather approaching the individual situation with a well thought-out plan that ensures all tools available will be used in the best possible ways. In this way, IPM addresses multiple social and environmental concerns and can create common ground for discussing pests and pesticides issues.

Closing Remarks

Dawn H. Gouge, Co-Chair, Symposium Steering Committee, dhgouge@email.arizona.edu, Department of Entomology—Arizona Pest Management Center, University of Arizona—MAC, Maricopa, AZ

concurrent sessions

1 • Resistance Management

Baltimore A

This mini-symposium will explore practices that contribute to resistance with "boots on the ground" perspectives and real life methods that can be deployed to reduce the development of resistance. Our speakers face challenges everyday as valuable pest management tools become less effective due to resistance. We know what causes resistance, but seem unable to prevent it. Listen to these experts share their views and solutions to this major challenge in pest management.

Organizer: Susan Ratcliffe, sratclif@illinois.edu, North Central IPM Center, University of Illinois, Urbana, IL

8:30 1.1 Introduction, Kaitlyn Bissonnette, bissonnettek@missouri.edu, University of Missouri, Columbia, MO

8:45 1.2 Tackling resistant insects in Nebraska field crops through integrated research and extension, Julie A. Peterson, julie.peterson@unl.edu, Department of Entomology, University of Nebraska–Lincoln, West Central Research and Extension Center, North Platte, NE

Arthropod pests have a long history of evolving resistance to the management practices that humans have used against them, including cultural, chemical, transgenic, and even biological controls. In the state of Nebraska, the western corn rootworm alone has evolved resistance to at least five classes of insecticides since the 1960s. The integrated research and extension approach that has been used in this state to better understand and manage the western corn rootworm and western bean cutworm will be described. The use of game theory to explain how growers' choices affect resistance has shown promise at preliminary extension activities.

9:10 1.3 Fungicide Resistance in Soybean, Andrew Penney, ajpenney@iastate.edu, Iowa State University, Ames, IA

9:35 1.4 Herbicide Resistance and Management—Changing our Mindset, Rakesh Chandran, rschandran@mail.wvu.edu, WVU Extension Service–AMR, West Virginia University, Morgantown, WV

Overdependence on herbicides has led to alarming levels of resistant weed populations in row crop-producing areas of the United States. Our quest to enhance agricultural productivity using simplistic approaches has been met by a concomitant and intrinsic ability of weeds to counter the same. As we select production practices that allow crops to flourish and adopt effective pest management strategies, we have been subconsciously selecting for weeds that thrive and multiply under such conditions. Although the number of weed species evolving resistance to commonly used herbicides has not increased exponentially since the widespread adoption of herbicide-tolerant crops, total area prone to herbicide-resistant weed biotypes has increased to alarming proportions. Thus far, attempts to address this emergent problem have largely been dependent on similar unrefined tactics albeit different chemistries. While chemical control is expected to play a significant role in IPM, certain checks and balances may be warranted to avoid losing otherwise valuable tools in crop production, and to reduce our dependence on them. The potential to reduce selection pressure, and hence total acres treated with herbicides in major crops exists and needs to be explored further. Strategies to shift from the conventional mindset of managing weeds to a more integrated and selfless approach without offsetting the IPM-equilibrium could improve our ability to manage resistant weeds in the future. Transdisciplinary approaches are required to meet the increasing global demand for food and fiber in a sustainable, eco-friendly manner and a diverse weed management approach will be a critical component.

10:15 1.5 Resistance in highly susceptible populations, Paul C. Jepson, paul.jepson@oregonstate.edu, Integrated Plant Protection Center, Oregon State University, Corvallis, OR

10:40 1.6 Strategies Used by Food Processors to Minimize Impacts of Pesticide Resistance, Todd DeKryger, todd.dekryger@us.nestle.com, Nestlé North America Procurement, Fremont, MI

A stable supply of high quality raw materials is the lifeblood of a food processor. Many factors, including quality issues due to pest contamination, can cause a disruption in the steady flow of crops into a processing facility. To assure a stable raw material supply, food processors incorporate many strategies. However, the successful strategies for one crop may not work on another crop. Add to the equation the elevated expectations that parents have for infant foods and the supply situation can get very complicated in a hurry.

11:05 1.7 An Overview of Social Science Research and Research Gaps on Resistance Management, Amanda Crump, acrump@ucanr.edu, Western IPM Center, University of California, Davis, Davis, CA

A strong pesticide resistance plan and protocol relies on the cooperation of growers, pest control advisers or crop consultants, pesticide applicators, extension personnel and researchers. Understanding the barriers that keep people from adopting good resistance management practices and identifying the opportunities that make it easier to adopt these management practices ensure that applicators and researchers work together to solve resistance problems or prevent resistance. This talk gives an overview of what social scientists, ranging from economists to sociologists, understand about pesticide resistance management and provides a list of research gaps where scientists and extension educators can work with social scientists to maximize the adoption of pesticide resistance management practices.

11:30 1.8 Discussion and Conclusion

2 • How Can Microbial Control Agents Fit into IPM? Examples from the Field

Baltimore B

Microbial control agents—viruses, bacteria, fungi—and entomopathogenic nematodes, have seen increasing development in the past two decades. The bacteria, particularly *Bacillus thuringiensis*, were early entrants into commercial agriculture. With entomopathogenic fungi, where in the 1970s there were only a handful of agents, there are now close to 200 commercial products worldwide. Viruses have also seen a substantial increase in use. Nevertheless, there are still disappointments and reluctance in adoption. One problem is that many times microbial agents have been cast into a chemical paradigm, in which the microbial is expected to perform like a chemical, as good as chemical, to simply replace a chemical. What is forgotten is that microbials should be one tool in a integrated system. This concept has been forgotten until the last few years. Recently, a number of efforts have been made to integrate microbials with other measures, from cultural practices to other biologicals, to create successful systems to manage insect pests. This symposium will present some real world examples—greenhouse crops, small fruit, cotton, coffee, and stone fruit—where microbials successfully complement other IPM tools to manage pest insects, to encourage similar adoption in additional crop systems.

Organizer: Stefan T. Jaronski, stefan.jaronski@ars.usda.gov, USDA ARS, Sidney, MT

8:30 2.1 Successfully integrating microbial biocontrol agents into production systems: Working examples from the Canadian greenhouse floriculture industry, Michael Brownbridge, michael.brownbridge@vinelandresearch.com, Horticultural Production Systems, Vineland Research and Innovation Center, Vineland Station, ON, Canada

Historically, the greenhouse floriculture industry has relied on synthetic insecticides to meet its pest control needs. However, growers are increasingly faced with the loss or failure of pest control products, declining access to new chemistries, stricter environmental/health and safety regulations, and the need to produce plants and vegetables in a manner that meets the demands of a retail/consumer driven market. In Canada, the failure of Spinosad (Success™) for thrips within 6 to 12 months of its registration provided the stimulus to change. Today, >70 per cent of Ontario growers use some form of biocontrol and certain crops are grown from start to finish without pesticides. Microbial insecticides play a critical supporting role in IPM. They have unique modes of action and are active against a range of challenging pests. As microbial insecticides have come to market, research to generate efficacy data has assisted their registration in Canada, and the development and adaptation of programs that incorporate these materials has promoted uptake by floriculture growers. Applied at strategic points in the production cycle, use of microbial insecticides successfully strengthens biologically-based IPM programs, resulting in more robust, efficacious and cost-effective systems. This presentation documents research trials carried out to define 'best practices' around the integration of microbial insecticides into floriculture production systems, outlines current use practices, and identifies opportunities to improve efficacy in ornamental crops.

8:50 2.2 The art, science, and economics of integrating microbial control into California strawberry and vegetable IPM, Surendra K. Dara, skdara@ucdavis.edu, Division of Agriculture and Natural Resources, University of California, San Luis Obispo, CA

California agriculture is diverse and dynamic, leading the nation in strawberry and vegetable production, among other commodities. IPM practices are well-promoted and generally well-adopted in both organic and conventional systems in California. Although microbial pesticides have been used for a long time, their potential is not fully exploited to consider microbial control as an important tool of IPM programs, especially in conventional agriculture. Improving microbial control adoption in California can have a significant impact in local agriculture as well as on guiding IPM programs elsewhere. The art of understanding microbial pesticides, their modes of action, and correct placement in IPM; the science of generating

efficacy data from multiple field studies against various pests in different crops; and the economics of purchasing, storing, and applying microbial pesticides play a critical role in the success of microbial control. Several field studies have been conducted in California strawberry and vegetable crops to evaluate the efficacy of microbial pesticides alone and in combination with other control options to identify potential IPM strategies. Research results and outreach impacts of microbial control in strawberry and vegetable programs will be discussed.

9:10 2.3 Incorporating microbial agents into IPM, Michael Dimock, mdimock@certisUSA.com, Certis USA, Columbia, MD

Baculoviruses have been used as commercial microbial insecticides in a number of agricultural cropping systems as well as in forestry. Their unique mode of action as highly virulent entomopathogens of a limited number of primarily Lepidopteran hosts presents very low risk of adverse effects to nontarget organisms and humans. This makes them good candidates for inclusion in IPM programs targeting caterpillar pests, given proper consideration of the challenges presented by limiting environmental factors such as solar UV irradiation, and operational factors such as tank mix compatibility. This presentation will provide IPM practitioners with a basic introduction to how baculoviruses work, how to recognize their action in the field, and best practices for implementing viral insecticides in IPM programs using historical and current examples of practical use.

9:30 2.4 Microbial Control Approaches for Orchard Pests: Focus on Pecan and Peach Systems, David Shapiro-Ilan, David.Shapiro@ARS.USDA.GOV, USDA-ARS, Byron, GA

Through our research, we have made major advancements in developing biocontrol options for orchard pests focusing on pecan and peach systems. Key pests included pecan weevil (*Curculio caryae*) in pecan, and peachtree borer (*Synanthedon exitiosa*) in peach. Pecan weevil: An integrated program was tested using entomopathogenic/beneficial nematodes (*Steinernema carpocapsae*), entomopathogenic fungi (*Beauveria bassiana*), and the bacterial-based product Grandevo® (*Chromobacterium subtsugae*); treatments were applied alone or in combination. An integrated approach (using entomopathogenic nematodes, fungi and Grandevo®) caused significantly lower nut damage compared with the non-treated control. Also, when compared with standard chemical insecticides, Grandevo® was equally effective in reducing pecan weevil damage. Peachtree borer: We applied the beneficial nematode, *S. carpocapsae* in the late summer and fall as a preventative application, and also tested *S. carpocapsae* as a curative treatment by applying the nematodes in the spring to borer-infested trees. Efficacy comparisons to standard chemical insecticides (chlorpyrifos) were also made. The nematode, *S. carpocapsae* reduced peachtree borer infestations and reduced peachtree borer survival in both preventative and curative applications. In preventative applications, the nematode treatments were equally effective compared with standard chemical insecticides (chlorpyrifos) and in curative applications *S. carpocapsae* was more effective than chlorpyrifos. In conclusion, biocontrol methods were highly effective in controlling pecan weevil and peachtree borer. Biocontrol options for control of other orchard pests such as plum curculio (*Conotrachelus nenuphar*) and lesser peachtree borer (*Synanthedon pictipes*) will also be briefly discussed.

10:15 2.5 Utilizing Naturally-Occurring Entomopathogenic Fungi in Cotton Aphid IPM, Donald Steinkraus, steinkr@uark.edu, Entomology Department, University of Arkansas, Fayetteville, AR

Cotton has historically been a crop requiring many chemical inputs for control of insect pests. During the 1980s and 1990s, the cotton aphid, *Aphis gossypii*, was frequently an important pest of U.S. cotton. Natural epizootics in the cotton aphid caused by the entomopathogenic fungus, *Neozygites fresenii,* were studied between 1989 and 1992. We discovered that we could diagnose fungal prevalences from aphids in cotton fields and make realistic predictions about the development of epizootics that reduced aphid populations as well as, or better, than insecticides. Based on this, we started a sampling service for cotton growers, scouts, and extension agents. Aphid samples were mailed to our laboratory, diagnosed for fungal prevalence, and recommendations provided to the growers that allowed them to make informed decisions on whether to treat with an insecticide or let epizootics reduce the aphids. This service started in Arkansas and was expanded to all the cotton growing states in the southeast. It operated for over ten years and was considered a major success for IPM and biological control in Arkansas.

10:35 2.6 Incorporating *Beauveria bassiana* in an Integrated Pest Management for Coffee Berry Borer in Hawaii, Luis Aristizábal, laristizabal721@gmail.com, Independent Consultant, Kailua-Kona, HI

Since the Coffee Berry Borer (CBB), *Hypothenemus hampei* (Coleoptera: Curculionidae), the most important pest in coffee plantations worldwide, was reported in Hawaii in 2010, coffee growers are facing reduction of yields, quality and price of coffee. Commercial formulations of *Beauveria bassiana*, was authorized. Two approaches were evaluated: 1) Calendar applications (6-10/ year); and 2) Applications only when are needed according to the sampling plan (4-6/year). Results showed that using *B. bassiana* was similar between both approaches, but it was less costly for the second option. An IPM for CBB applying *B. bassiana* when CBB is colonizing berries and conducting sanitation have showed the best results for control CBB in Hawaii.

3 • The Added Value of Amendments in Turfgrass IPM

Guilford

Turfgrass is the most widely planted specialty crop and offers numerous social, economic, and environmental benefits. As turfgrasses are grown throughout the world, they encounter diverse and often challenging environments. They are often subject to both biotic and abiotic stressors that can limit survival thereby requiring fertilizer, water, and pesticides to maintain healthy, dense stands of turf. In recent years, fertilizer and pesticide use has become a public concern resulting in numerous state and local laws regulating and/or banning the use of certain products. To develop more sustainable turfgrass management, a growing trend involves the use of added-value products such as composts, compost extracts, biostimulants, microbial inoculants, and biopesticides. When applied correctly, these products can have positive effects on turfgrass through nutrient supply and acquisition, enhancement of beneficial microflora, and reductions in pests while being more environmentally friendly than some synthetic alternatives. The proposed session will provide an in-depth overview of turfgrass amendments, both from a historical perspective to those used today in establishing effective IPM turf programs. The audience will be engaged in active learning through interactive polling software that will provide real-time feedback. Individual scenarios will provide opportunity for attendees to discuss previous experience. Session organizers will discuss and illustrate beneficial and detrimental impacts associated with amendment applications along with realistic expectations for future implementation. Lastly, attendees will gain insight into current research designed to harness the power of microbial communities associated with turfgrass ecosystems, which is an emerging research area in developing IPM strategies for turfgrass production.

Organizer: Joseph Roberts, robertsj@umd.edu, Plant Science and Landscape Architecture, University of Maryland, College Park, MD

8:30 3.1 Nutrient Management Considerations for Compost Applications Made to Turfgrass, Mark Carroll, mcarroll@umd.edu, Plant Science and Landscape Architecture, University of Maryland, College Park, MD

9:00 3.2 Nitrogen Source and Biostimulant Effects on Turfgrass Pest Management, Thomas Turner, tturner@umd.edu, Plant Science and Landscape Architecture, University of Maryland, College Park, MD

9:30 3.3 Implementing Organic Amendments to Reduce Turfgrass Pathogens, Joseph Roberts, robertsj@umd.edu, Plant Science and Landscape Architecture, University of Maryland, College Park, MD

4 • Application of Trap and Cover Crops in Integrated Pest Management

Homeland

Trap cropping has been one of the best alternative way of controlling insect pests in absence of insecticidal use. It is an environmental friendly approach with no risk of pesticide resistance in which trap crops are planted either in row intercropping or along border to protect the main crop from the certain pest. They attract insects or other organisms to protect main or target crop. Trap crops as plant stands that are, per se or vis manipulation, deployed to attract, divert, intercept, or retain targeted insect or pathogens they vector in order to reduce damage to main crop. They can serves as sink, in which pest offspring cannot survive and thus, preventing pest movement from trap crops to main crop. Trap cropping focuses on plant and pest interaction that is habitat manipulation for biological control of pest. Plant breeders have developed many cultivars that are able to attract insect pest and natural enemies, and low larval survival. According to Hokkanen (1991), only 10% area can be utilized for trap crop to protect the main crop and about forty successful cases of trap crops are described. On the other hand, cover crops bring a host of benefits to farms of all types including regulating the insect pest populations. By improving soil health and fertility, cover crops contribute to pest management.

Organizers: Gadi V.P. Reddy, reddy@montana.edu, Western Triangle Ag Research Center, Montana State University, Conrad, MT; Govinda Shrestha, govinda.shrestha@montana.edu, Western Triangle Ag Research Center, Montana State University, Conrad, MT

8:30 4.1 Role of Trap and Cover Crops in IPM, Heikki M.T. Hokkanen, heikki.hokkanen@helsinki.fi, Department of Agricultural Sciences, University of Helsinki, Finland

The use of trap and cover crops can facilitate the full exploitation of all eight fundamental IPM-principles, as defined in the European Union's "IPM-Directive." The most important part of IPM is the prevention and/or suppression of harmful organisms (IPM Principle #1), and this is where trap and cover crops can give their biggest contribution to pest, weed and disease control. In this presentation I will analyze and provide examples for the contributions of trap and cover crops to each of the eight IPM principles, and will discuss their potential in novel contexts such as for RNAi-based control options.

9:10 4.2 Developing a trap crop method for BMSB based on insect behavior, Anne L. Nielsen, nielsen@aesop.rutgers.edu, New Jersey Agircultural Experment Station, Department of Entomology, Rutgers University, Bridgeton, NJ

The invasive brown marmorated stink bug, *Halyomorpha halys*, poses significant risk to organic farming systems. In multi-state studies we identified two potential crops for *H. halys* and planted them as a polyculture trap crop surrounding organic sweet peppers at 11 sites in the U.S. Stink bug densities and injury were compared between trap crop-protected and unprotected peppers. Using a combination of mark-recapture techniques, the trap crop retention was evaluated. Although attractive, without additional management, *H. halys* moved off the trap crop and caused injury in the peppers. Under high population pressure, a trap crop alone did not reduce crop injury.

9:30 4.3 Large-scale trap crop research and demonstration efforts in Alabama for managing leaf footed bugs and squash bugs, Ayanava Majumdar, azm0024@auburn.edu, AU Department of Entomology and Plant Pathology, Auburn University, Auburn, AL

Tomato and squash are at very high threat of direct crop losses from sucking insect pests such as leaffooted bugs (*Leptoglossus* spp., Hemiptera: Coreidae) and squash bugs (*Anasa tristis*, Hemiptera: Coreidae). In large-scale tomato production research, perimeter trap crops consisting of NK-300 sorghum and Peredovik sunflower attracted over 80 percent leaffooted bugs thereby enhancing quality of tomato (main crop). A perimeter trap crop with Hubbard squash had similar effect on squash bugs with 50 percent or more reduction of pest on yellow squash. Proper integration with other control methods, such as insecticides, can further enhance crop protection and produce quality.

9:50 4.4 Effects of cover crops on Coleoptera assemblages in tea plantations, Li-Lin Chen, nic.irvin@ucr.edu, Fujian Agriculture and Forestry University, State Key Laboratory of Ecological Pest Control for Fujian and Taiwan Crops, Institute of Applied Ecology, Fuzhou, Fuzhou, China; GaborPozsgai; Min-Sheng You

Coleoptera are prominent members of food webs in tea ecosystems, represented with high species richness and abundance. Many tea pests and natural enemies belong to this order, therefore; knowledge on how management practices affects food web is likely to be of pest management interest. Sweep net and knock-down samples were collected monthly, between May 2006 and April 2008, in a replicated field experiment, in tea with differing groundcover treatments and Coleoptera diversity indices analyzed. Tea intercropped with *Chamaecrista rotundifolia* (Pers.) Greene or *Paspalum notatum* Flüggé, and tea on bare ground had significantly greater mean species richness than did tea with natural ground cover. Shannon's diversity index showed similar trends but with significant differences only between *C. rotundifolia* (Pers.) Greene intercrop and natural vegetation. Mean abundance of Coleoptera did not differ across treatments, however after the removal of the superabundant *Haptonchus luteolus* Erichson, the most abundant species in our samples, a significant difference between *C. rotundifolia*.

10:15 4.5 Habitat Manipulation and Management of Vegetable Pests, Hugh Smith, hughasmith@ufl.edu, Gulf Coast Research & Education Center, University of Florida, Wimauma, FL

Habitat manipulation involves providing and protecting vegetative resources that beneficial arthropods can use for food and shelter in and around agricultural areas. The purpose of habitat manipulation is to enhance the activity predators and parasitoids in suppressing pests. Nectar and pollen are important floral resources for some parasitic wasps, syrphid fly adults, and predators. In addition, provisioned habitat can provide alternate prey or hosts for predators and parasitoids, enabling natural enemies to establish stable populations near crops at risk of infestation. Examples of habitat manipulation from the central coast of California and the Guatemalan highlands will be discussed.

10:35 4.6 Use of the difference in preference of weevils to sweetpotato varieties to reduce damage: A push-pull management, Katsuya Ichinose, ichis@affrc.go.jp, Tropical Crop Protection, Kyushu Okinawa Agricultural Research Center, KARC, Itoman, Itoman, Japan; Mutsuhiro Yoshida; Gadi V.P. Reddy

The difference in the preference of sweetpotatoes to the weevils, *Cylas formicarius* and *Eucepes postfasciatus*, may be incorporated into the management of these insects. We tested this hypothesis by planting sweetpotato varieties, Beni-masari, Churakoi-beni and K166, to which weevils prefer less in this order. Churakoi-beni and K166 planted with Beni-masari were less infested by weevils than those without it. The application of bio- and chemical-agents enhanced the reduction of weevil damage on the two varieties. Thus, the difference in weevil preference to varieties could be incorporated into the management of weevils as a part of Push-Pull.

10:55 4.7 Can red clover play a role in conventional and organic IPM programs, Cerruti R.R. Hooks, crrhooks@umd.edu, Department of Entomology, College of Computer Mathematical and Natural Sciences (CMNS), University of Maryland, MD; Hanna M. Kahl; Alan W. Leslie

Red clover is grown worldwide to improve soil structure, soil N and organic matter content which enhances crop resilience. Its low growth characteristic allows it to be grown as an interplanted cover crop among cash crops. Our research

goals include investigating the pest management potential of using red clover as an interplanted living mulch. It is believed that red clover living mulch can be used to help manage insect and weed pests in conventional and organic cropping systems. The impact of red clover on insect herbivores, beneficial arthropods, weeds and marketable yields within cucumber and pepper plantings will be discussed.

11:15 4.8 Trap crops for wireworm management, Anamika Sharma, anamika.sharma@montana.edu, Western Triangle Agriculture Research Center, Montana State University, Conrad, MT; Ashish Adhikari; Gadi V.P. Reddy

Wireworm are major pests of spring wheat. As the substitute of chemical control, trap crops are being explored. In the 2015-2016 study, pea and lentil are found to be effective to attract wireworm larvae. In 2017, different seed rates of pea and lentils were tested—P4, P8, P14 and L6, L12, L18—with spring wheat sown at the rate of W11, W22 and W28. Both pea and lentil performed significantly well at the rate of P8 and L12 respectively. Same rate is observed to attract more wireworm and therefore higher spring wheat yield is found to be associated at this rate.

5 • Assessment-Based Pest Management (APM)—Why We Must Make Monitoring and Pest Assessment the Foundation of all Structural Pest Management!

Fells Point

Integrated pest management (IPM) is a term widely used in both the agricultural and the urban environment. While agricultural IPM is known to be based on assessing pest levels prior to pesticide application, this concept is completely lost in the urban environment. Economic injury or threshold levels do not exist… How many bed bugs would your mother put up with before applying a pesticide? The managers of low income housing, and other pest-prone facilities have no knowledge of what is meant by IPM. They assume it is some low toxicity, or non-pesticidal method for treating pests. They do not understand that IPM requires that treatment decisions be made based on an assessment of their pest levels. US HUD encourages housing owners/operators to develop an IPM plan for preventing and treating bed bug and other pest infestations. However, the HUD on-line portal describing bed bug IPM (taken from the US EPA IPM principles for bed bugs) does not even mention monitoring or assessment. The consequence of this lack of IPM understanding has caused housing authorities to pay excessive amounts for IPM services that are completely ineffective. In addition, residents are routinely left infested, and ultimately blamed for pest management failures. In this symposium we will cite real-world examples of how assessment-based programs have proven essential for pest management success. We will also discuss why the term IPM should be converted to APM so that all housing managers understand that pest assessment is the foundation of their pest management program.

Organizers: Dini Miller, dinim@vt.edu, Department of Entomology, Virginia Tech, Blacksburg, VA; Michael Scharf, mscharf@purdue.edu, Department of Entomology, Purdue University, West Lafayette, IN

8:30 5.1 Resistance Assessment for making pesticide choices, Michael Scharf, mscharf@purdue.edu, Department of Entomology, Purdue University, West Lafayette, IN

This talk will cover new insights from HUD sponsored research on managing cockroaches and associated allergen loads in public housing. Specific topics to be covered will include insecticide resistance monitoring, calibrating monitoring results against field control efforts, and how/when to integrate diverse PM approaches in resistance management programs.

8:50 5.2 Assessing Pest Manager Knowledge and Performance, Faith Oi, foi@ufl.edu, Department of Entomology and Nematology, University of Florida, Gainesville, FL

Assessing pest problems requires the ability to identify pests in the field and then develop a management strategy based on the biology of that pest. We will present several years of pre- and post-test data by pest control category and position in company.

9:10 5.3 Pest Risk Assessment: A tool for engaging IPM in the Urban Environment, Gene D. White, gene.white@rentokil.com, RentoKil, RentoKil-Initial, Richmond, VA

9:30 5.4 Assessment-based Pest Management for Bed Bugs in Multifamily Housing, Rick Cooper, rick.cooper@cooperpest.com, Rutgers University, New Brunswick, NJ

Bed bugs are among the most challenging of pests affecting multifamily housing communities. Typically, bed bug infestations are treated on a reactionary basis, after they have been reported by residents. Failure to detect bed bugs early after their introduction enables infestations to become well established, making them more difficult and costly to control, and more likely to spread to other apartments in the community. Unfortunately, only about 1/3 of the apartments with bed bug activity are reported to property management by residents. An assessment-based bed bug management program is necessary in housing communities experiencing escalating infestation rates. The program should include building/community-wide inspection to identify unreported infestations and to enable complex-wide management of bed bugs. This presentation will demonstrate the need for an assessment based approach to bed bug management in multifamily housing.

10:15	5.5	APM: What are the costs?, Dini Miller, dinim@vt.edu, Department of Entomology, Virginia Tech, Blacksburg, VA
10:35	5.6	Challenges that technicians faceand perspectives on how assessment can be priced into an contract, Nancy Troyano, Nancy.Troyano@rentokil.com, Rentokil, RentoKil, Reading, VA

When it comes to treating for bed bugs, there are many challenges that technicians face during their services which can affect their ability to deliver on what was promised to the customer. As a result, the infestation persists, leading to multiple callbacks and unhappy customers. In order to minimize these occurrences, potential challenges and risks must be taken into consideration during the initial assessment with the customer. Those risk factors should be incorporated into the contract to ensure that the job is priced reasonably enough to deliver a successful treatment and be profitable to the company.

10:55	5.7	APM: The HUD Perspective, Rachel Riley, Rachel.M.Riley@hud.gov, US Department of Housing and Urban Development, Office of Lead Hazard Control and Healthy Homes, Washington, DC

Rachel will provide insight and issues with pest control in low-income housing.

11:05	5.8	IPM in public housing and relationship to asthma, Ken Strong, ken.strong@habc.org, Housing Authority of Baltimore City, Baltimore, MD

Ken will present the HABC's pest control program and asthma interventions.

6 • The Great Challenge: Communicating IPM to a Public Audience

Federal Hill

IPM is among the world's best-kept secrets. But how is it that an approach that benefits so many can be understood by so few? One reason might be the challenge of translating science into a common language. This is true for all of science; not only IPM. However, IPM is a complex, iterative decision-making process. IPM work is unique in every context, and very difficult to capture in a single, simple explanation.

For decades there has been a tendency to assume that if we only had better writing, better graphics, a clever slogan, access to user-friendly technology, or more resources, we could breakthrough this logjam. Cognition scientists would disagree. They teach us that to change how a person thinks, you have to first understand their "active frames"—the stories people tell themselves about how the world works. People insert facts and new information into preexisting frames, usually without changing the underlying idea (their frame). Effective communication of new concepts or fresh information involves a constant reframing of basic stories.

The workshop content includes (a) cognition science—how people receive and digest information, both scientific and otherwise; (b) the current challenges facing three IPM communication projects, two of them just launched; and (c) insights on how reframing stories offers opportunities to increase the understanding and adoption of IPM.

Organizer: Michael A. Rozyne, mrozyne@redtomato.org, Red Tomato, Plainville, MA

8:30	6.1	Cognitive Science/Framing for Farming, Michael A. Rozyne, mrozyne@redtomato.org, Red Tomato, Plainville, MA
8:45	6.2	Expanding the Dialogue: The Pests, Pesticides, and IPM Project, Lori Berger, lberger@ucanr.edu, UC Statewide IPM Program, Kearney Agricultural Center, Parlier, CA
9:00	6.3	IPM Communications and the Food Narrative Project, Sue Futrell, sfutrell@redtomato.org, Red Tomato, Plainville, MA

7 • Weather Driven Epidemiological Forecasts for Efficient IPM Strategies

Guilford

Climate and weather-driven forecast systems play important roles for a wide range of management applications at many spatial scales (farm to region). Pest forecast systems are widely used by farmers not only to predict suitable timings for planting, spraying pesticides, and harvest schedules but also to manage cost-effective production. Pest forecast systems are also useful for regional management frameworks (regulatory agencies; state-level management, multi-state coordinated efforts, nationwide management and even international-level management) allowing them to create early warning systems as well as to manage invasive pests that are already established in a given location. This session will highlight how weather-driven forecasts can assist to develop efficient IPM, to make better decisions, to protect crops from agricultural diseases and other pests, and to address current challenges. There will be four main topics presented in this session; 1) availability and quality of weather data for pest forecasts, 2) pest prediction and forecast systems, 3) uncertainty associated with pest forecasts, and 4) decision making based on pest forecasts for extension agents and farmers. These presentations will be followed by a session discussion to address current challenges and limitations and to identify critical research needed to strengthen IPM strategies. The collaboration among wide range of expertise can help construct better pest forecast systems and manage agricultural pests more efficiently.

Organizers: Roger Magarey, rdmagare@ncsu.edu, NCSU Center for Integrated Pest Management, Raleigh, NC; Yu Takeuchi, yu_takeuchi@ncsu.edu, NCSU Center for Integrated Pest Management, Raleigh, NC

10:15 7.1 Plant pest forecast systems, Yu Takeuchi, yu_takeuchi@ncsu.edu, NCSU Center for Integrated Pest Management, Raleigh, NC

Plant pests cause significant economic and ecological damage to managed and natural U.S. forests and agricultural landscapes. It is essential to have effective management plans to control and minimize the damage caused by plant pests. Pest forecast systems can predict pest behaviors and identify potential damages and risks associated with plant pests and assist developing near real time pest management plans for farmers and land managers. In this presentation, basic concepts and benefits of plat pest forecast systems are discussed.

10:20 7.2 Availability, accessibility, and quality of weather and climate data in support of global pest forecasting models, Heather Aldridge, heather_aldridge@ncsu.edu, NCSU State Climate Office of NC, Raleigh, NC

Pest forecast models rely on global datasets of temperature and precipitation to provide atmospheric conditions at a variety of spatial and temporal resolutions. Determining the availability, accessibility, and quality of this weather and climate data can often be challenging. Point-based observations are sparse in some locations while gridded data sets provide better spatial coverage. However, both have associated error metrics and a variety of non-standard formats. This presentation will highlight resources and barriers for obtaining these data to meet the needs of global pest forecast models.

10:40 7.3 Pest Modeling for the 21st Century, Roger D. Magarey, rdmagare@ncsu.edu, NCSU Center for Integrated Pest Management, Raleigh, NC

The integrated Pest Information Platform (iPiPE) is an example of a modern pest forecasting system. The iPiPE was developed to promote the sharing of pest observations between growers, industry and Extension. The iPiPE uses grid weather databases to deliver pest models at a 2.5 km resolution in the US48. I provide three pest examples of how models can be incorporated into iPIPE, including western bean cutworn, spotted wing drosophila and soybean sclerotina stem rot. Incorporation of models into iPiPE allows models to be shared with 3rd party websites via an API and validated using iPIPE observations.

11:00 7.4 Predictive Systems for Pest Management: Utility for Extension and Farmers, Frank Louws, frank_louws@ncsu.edu, NCSU Center for Integrated Pest Management, Raleigh, NC

Predictive systems to optimize pest management decisions are designed to be accessible to users based on science-based integration of pest biology, environmental factors, crop production systems and sociological dynamics. Systems can vary in complexity from "rules of thumb" to multicriteria-based systems. Predictive systems enhance conceptual knowledge of researchers and extension leaders with an intended beneficial impact for end-users. Examples from North Carolina and other regions will highlight key benefits, opportunities and challenges with current and emerging predictive systems. Emphasis will be on real-world examples and variable system impacts on costs of production, enhanced efficacy, resistance management and reduced pesticide loads.

11:20 7.5 Discussion

8 • Communicating IPM to Diverse Audiences

Federal Hill

Scientists, green industry, state personnel, Master Gardeners and policy makers must share information to make informed decisions about pesticide use and integrated pest management in outdoor urban areas but these groups often speak different languages. How can we best communicate with and engage policy makers who make judgements about pesticide prohibitions and restrictive policies for pest management? We will address outreach efforts, bilingual educational materials, training programs, diagnostic resources and political testifying techniques to support your efforts to promote IPM and protect plants from the threat of new invasive species, increase early detections and retain pesticides as one of the IPM tools used to preserve plant and ecosystem health.

Organizer: Mary K. Malinoski, mkmal@umd.edu, Home and Garden Information Center, University of Maryland Extension, Ellicott City, MD; David L. Clement, clement@umd.edu, Home and Garden Information Center, Ellicott City, MD

10:15 8.1 Educational Outreach Efforts on Diagnosis of New and Invasive Insects and Diseases to Green Industry Workers, Part I, Mary K. Malinoski, mkmal@umd.edu, Home and Garden Information Center, University of Maryland Extension, Ellicott City, MD

Ongoing educational training and outreach programs for Maryland Extension have focused on helping Green Industry workers with identifying new invasive insects. Educational materials include Spanish translations of invasive ID cards that are aimed at Hispanic workers to increase early detection of Asian longhorned beetle, Spotted lanternfly, and boxwood blight. Most Green Industry personnel including Hispanic workers use smart phones so they are able to utilize the MAEDN (Mid-Atlantic Early Detection Network) app to identify and report invasive pests and diseases.

10:30 8.2 Educational Outreach Efforts on Diagnosis of New and Invasive Insects and Diseases to Green Industry Workers, Part II, David L. Clement, clement@umd.edu, Home and Garden Information Center, University of Maryland Extension, Ellicott City, MD

Ongoing educational training and outreach programs for Maryland Extension have focused on helping Green Industry workers with identifying new diseases. Current efforts also include a focus delivering outreach materials to Hispanic workers. The new disease educational materials include sudden oak death, oak wilt, and boxwood blight. A large bi-lingual poster that includes additional pests and diseases has been created for use in common areas at nurseries and landscape care facilities. Bi-lingual trainings have been arranged for the coming spring.

10:45 8.3 Training Improving communication between public gardens, diagnostic labs and regulatory officials, Rachel L. McCarthy, rachel.mccarthy@cornell.edu, NPDN-SPN Coordinator,Plant Pathology and Plant-Microbe Biology Section, School of Integrative Plant Science, Cornell University, Ithaca, NY

The First Detector program promotes the early detection of significant plant pests and pathogens. Horticulture inspectors, growers, public garden professionals, Sentinel Plant Network participants, Master Gardeners and homeowners have participated in First Detector training workshops or have completed the First Detector online training course. This training is used by the Sentinel Plant Network with the American Public Gardens Association to improve the detection of high-consequence plant pests and pathogens. First Detector training and improved diagnostic resources increases early detection and improves communication between public gardens, diagnostic labs and regulatory officials.

11:15 8.4 Communicating IPM to Policy Makers, Jody Fetzer, Jody.fetzer@montgomeryparks.org, Plant Health Horticulturist, Montgomery Parks, Horticulture, Forestry and Environmental Education Division, M-NCPPC, Gaithersburg, MD

Scientists, green industry, state personnel, Master Gardeners and policy makers must share information to make informed decisions about pesticide use and integrated pest management, but these groups often speak different languages. Jody will share communication tips to inspire you to inform and engage policy makers who make judgements about pesticide prohibitions and restrictive policies for pest management. Training methods & maintenance techniques to help staff with pest challenges in public spaces such as playgrounds, athletic fields, parks and public gardens.

9 • Social and Economic Aspects of IPM

Baltimore A

In integrated pest management (IPM), the species whose behavior is most difficult to explain or manage is *Homo sapiens*. This symposium considers the human element in integrated pest management. It will focus on the role of social sciences in understanding decision making, evaluating outcomes and impacts, and providing policy recommendations. Examples will be drawn from area-wide insect and weed control programs, diffusion of insect-resistant and herbicide-tolerant crop varieties, analysis of farmer belief systems, IPM adoption determinants and impacts in developing countries, and management challenges in urban IPM. The symposium will highlight the role of social sciences in understanding and aiding IPM programs. It will also consider how close collaboration among social agricultural, biological, and physical sciences improves IPM evaluation and program delivery. The first session will include presentations on frameworks applied by economists and by sociologists to understand and evaluate pest management. These approaches suggest advantages in considering seed variety, insect control, and weed control together in a more comprehensive fashion. Likewise, grower pest and resistance management choices may be better understood in a broader context of social networks. After the break, the second set of presentations will address quite distinct applications of IPM. One is farm level IPM implementation in developing countries, while the other considers urban IPM applied to U.S. schools in Texas. These presentations highlight the diverse set of challenges in delivering IPM programs. They also set the stage for discussion about methods and challenges in evaluation of program success.

Organizer: George B. Frisvold, frisvold@ag.arizona.edu, Agricultural & Resource Economics, University of Arizona, Tucson, AZ

1:15 9.1 Softening Shock and Awe Pest Management with IPM Principles, Terrance M. Hurley, tmh@umn.edu, Applied Economics, University of Minnesota, St. Paul, MN

Crop protection in corn, cotton and soybean production has increasingly focused on the seed. Whether through traditional breeding, genetic engineering, or seed coating, introducing insecticidal, fungicidal, and herbicide tolerant characteristics into and onto the seed farmers' plant has important implications for the durability, profitability, and human and environmental health consequences of crop protection. While some implications are positive, others are not. This presentation reviews current trends in crop protection and the implications of these trends. It then discusses how principles of integrated pest management (IPM) might be reimagined to seek a more favorable balance between the positive and negative consequences of crop protection.

2:00 9.2 The Social Context of Farmer Weed Management Practices, Raymond A. Jussaume, jussaume@msu.edu, Sociology, Michigan State University, East Lansing, MI

The agricultural social sciences have a long history of studying farmer decision-making. Much of the early research in this field fell under the Diffusion of Innovation framework, which was focused on identifying the individual characteristics of "progressive" farmers who were early adopters of modern agricultural technologies. Over time, this research field has evolved in various ways. One was is a widening focus that is no longer solely concerned with the adoption of new technologies, but also includes how and why farmers adopt new farming strategies, such as sustainable agricultural practices. Another is that researchers now also examine farmer social contexts, including structural position and social networks, in order to develop a more nuanced understanding of how farmers make decisions. The research presented herein builds upon that tradition by examining how farmers select weed management strategies for their farms. Empirical evidence from both qualitative and quantitative analyses is presented.

3:00 9.3 Cost, IPM, and Measuring the Success of School IPM Programs: Lessons Learned from a 20-year Mandate, Janet A. Hurley, jahurley@ag.tamu.edu, Department of Entomology, Texas A&M AgriLife Extension, Dallas, TX

To protect children, the Texas Legislature passed a law in the early 1990's requiring that Integrated Pest Management (IPM) practices be used to manage pests in and around school facilities. The rules require each school board in Texas adopt an IPM policy consistent with the laws governing pesticide use and proven IPM principles. Schools must make their policy available for the public to review. Each district is required to designate an IPM Coordinator who is responsible ensuring that the school follows the IPM policy. The IPM Coordinator's responsibilities include educating staff about the IPM program, monitoring for pest problems, and scheduling and keeping records of all pesticide applications made on District property. TDA is required by law to inspect 20% of Texas schools each year. In 2016, the Texas A&M AgriLife Extension Service School IPM Team sent a pest management survey of to all Texas public school districts. The objectives of the survey were to: (1) assess compliance with requirements of the Texas Department of Agriculture School IPM rules, (2) assess adoption of IPM policies, programs, and practices, and (3) evaluate how school IPM training relates to adoption of IPM and its concepts. Results of the survey represent 15% (n=155) of the schools in the state of Texas; however, in combination with the TDA compliance data, the School IPM Coordinator training workshops conducted each year by the team, and other communications with schools and pest management professionals, we have a very clear idea how this rule has favorably impacted Texas Schools.

3:30 9.4 Obstacles to Widespread Diffusion of IPM in Developing Countries: Lessons from the Field, Jeffrey Alwang, alwangj@vt.edu, Department of Agricultural & Applied Economics, Virginia Polytechnic Institute & State University, Blacksburg, VA

Despite IPM's promise to reduce pesticide use and lead to more environmentally safe and healthful foods in developing country, its adoption and spread has been disappointing. Multiple socio-economic and institutional factors inhibit the spread of IPM and this presentation presents a summary of evidence from the field. It then focuses on a key challenge: the complexity of IPM "packages" and how this complexity contributes to lagging adoption.

4:00 9.5 Discussant, Amanda Crump, acrump@ucanr.edu, Western Integrated Pest Management Center, University of California, Davis, Davis, CA

10 • Integrated Pest and Pollinator Management (IPPM): Integrating Pollinator Protection into Fruit and Nut IPM Programs

Baltimore B

While pesticides can be harmful to pollinators, when they are used in an integrated pest and pollinator management (IPPM) context, both pest management and pollinator protection may be achieved. Our growing knowledge of the impacts of pesticides on honey bees as well as bumble bees and solitary bees allows us to use the latitude we have in pest management including non-pesticidal pest management practices, changing pesticide types and incorporating other, less susceptible pollinator species into commercial practice. Pollinator health should be a central component of integrated pest management research, education and extension to produce viable IPPM approaches. Perennial fruit and nut crops are highly dependent of both managed and wild pollinators in various regions of the US to produce commercial crops. Although these high-value crops are intensively sprayed with insecticides and fungicides, they have highly developed IPM programs that try to minimize pesticide use and protect biological control agents to prevent secondary pest outbreaks. These IPM programs are currently being modified to protect pollinators by better understanding the routes and levels of exposure, lethal and sub-lethal impacts, to change IPM practices such as timing and pesticide selection that can help minimize possible pollinator impacts. Although some may say that we are in a pollinator crisis mainly based on honeybee declines, we assert that in addition to honey bee protection, we need to encourage and make use of the myriad other pollinator species and, by properly adjusting crop IPM practices to create IPPM that will protect all the pollinator species.

Organizers: David Biddinger, djb134@psu.edu, Entomology FREC, Penn State University, Biglerville, PA; Ed Rajotte, uvu@psu.edu, Entomology, Penn State University, State College, PA

1:15 10.1 Importance of Wild Pollinators and Habitat in Agriculture, Mace Vaughan, mace@xerces.org, Xerces Society for Invertebrate Conservation, Portland, OR

Over the past two decades, research into the pollination delivered by wild bees supported by habitat in and around agricultural landscapes has led to a greater appreciation for the need to protect these insects from pesticide exposure. In this talk, Mace will provide an overview of the science on the value of wild bees and habitat for supporting crop pollination, thus setting the stage for why Integrated Pest and Pollination Management is important for the protection of these pollinators and long-term sustainability of crop pollination.

1:30 10.2 Apple grower pollination practices and perceptions of alternative pollinators in New York and Pennsylvania, Neelendra Joshi, nkjoshi@uark.edu, Entomology, University of Arkansas, Fayetteville, AR; Mia Park, Biology, University of North Dakota; Bryan Danforth, Cornell University; David Biddinger, Penn State University; Ed Rajotte, Penn State University

1:45 10.3 Integrated Pest and Pollinator Management (IPPM) in Pennsylvania Apple Orchards, David Biddinger, djb134@psu.edu, Entomology FREC, Penn State University, Biglerville, PA; Ed Rajotte, Penn State University; Neelendra Joshi, University of Arkansas

Integrated Pest and Pollinator Management (IPPM) is an expansion of the IPM approach that accommodates pollinator health. While IPM programs simultaneously address economic, environmental and social goals, the ability of IPM decision-making to evolve in response to new demands is one of the reasons that IPM is still viable after more than 50 years. We show in commercial apple production that by carefully selecting pesticides and adjusting application timing, pest populations can be reduced while preserving the pollinators to set the fruit. Specifically, we trace the change in neonicotinoid concentrations as they are transported to the pollen and nectar to calculate the time necessary to eliminate toxicity.

2:00 10.4 Risks and rewards—Balancing the needs of pest control and pollinator protection in Michigan fruit crops, Julianna Wilson, jkwilson@msu.edu, Entomology, Michigan State University, East Lansing, MI; Rufus Isaacs, Michigan State University

2:15 10.5 Pollinator Conservation Programs Available to Growers through USDA-NRCS, Jim Gillis, james.gillis@pa.usda.gov, USDA-NRCS, Harrisburg, PA

2:30 10.6 USDA-NIFA Grant Programs to Protect Pollinators in Specialty Crops, Mary Purcell-Miramontes, MPURCELL@nifa.usda.gov, USDA-NIFA, Washington, DC

The National Institute of Food and Agriculture (NIFA) provides leadership and funding for research, extension and educational programs that advance agriculture-related sciences. We invest in and support initiatives that ensure the long-term viability of agriculture. NIFA recognizes the enormous challenges posed by unprecedented losses of animal pollinators and the need to better understand the causes of these declines as well developing strategies to ensure pollinators are protected in agroecosystems. This presentation will be an overview of NIFA's current funding programs in pollinator health as well as highlights of notable project impacts.

11 • IPM on Rangeland: Accomplishments and Challenges

Guilford

Implementation of IPM on rangeland experiences significant difficulties. The main one consists in the fact that rangeland forage—the main rangeland commodity—is of relatively low value compared to agricultural crops. Therefore, Economic Thresholds for rangeland pests are quite high and IPM methods developed on rangeland must have minimal costs to be viable. Evidently, this is a serious impediment for developing IPM options involving expensive insecticides or biological controls. Nevertheless, there are certain proven IPM strategies on rangeland, which are implemented worldwide. One of them is grasshopper and locust control with Reduced Agent and Area Treatments (RAATs)—an approach which combines chemical and conservation biological control. This program uses lower levels of insecticides (compared to traditional levels) and treating alternating (but not necessarily equal) strips of rangeland. With this strategy, grasshopper treatment efficacy diminishes slightly, compared to traditional methods; however, the environmental benefits increase through creating zones of refugia (untreated swaths) for non-target arthropods and other animal populations. RAATs have been successfully used for grasshopper control in 17 western states and in many countries overseas. For example, in 2010 in Wyoming, over 6 million of rangeland acres were protected with RAATs at an average cost of only $1.25 per protected acre with economic benefit of $13 million for stakeholders.

Accomplishments and challenges of this and certain other IPM strategies on rangeland will be discussed during the proposed session by a number of specialists from all over the world: USA, Australia, Canada, Uzbekistan, Argentina, Azerbaijan and Russia.

Organizer: Alexandre V. Latchininsky, latchini@uwyo.edu, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY

1:15 11.1 The PIS System for grasshopper IPM, Stefan Jaronski, stefan.jaronski@ars.usda.gov, Northern Plains Agricultural Research Laboratory, USDA ARS, Sidney, MT; David Branson, USDA-ARS-NPARL; Larry Jech, USDA-APHIS-PPQ-S&T-CPHST

Historically, grasshopper control in the U.S. meant crisis responses to outbreaks by treating large areas of rangeland with chemical insecticides. In the late 1980s USDA APHIS created a more IPM approach, using extensive twice yearly scouting, attempts at predicting when and where outbreaks could occur, and treating only 'hotspots.' During the past several years USDA ARS researchers, has been formulating an alternative approach, termed "Grasshopper PISS," for Prevention, Intervention, Suppression System. Within this concept emphasis is placed on prevention of outbreaks by use of rotational grazing, controlled burns. Intervention is performed only in those discrete areas with above threshold, damaging numbers of grasshoppers as identified by extensive APHIS scouting in all the Western States. "Control" is really suppression of outbreaks with reduction of population numbers to below a threshold, not total elimination. Only diflubenzuron and a carbaryl bait are used by the federal agency. Both ARS and APHIS have been developing microbial tools to replace chemicals in environmentally sensitive areas.

1:27 11.2 The "Why and How" Reduced Area Agent Treatments (RAATs) was developed to manage rangeland pest grasshoppers with lowered cost and reduced environmental impact, Scott P. Schell, sschell@uwyo.edu, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY; Alexandre V. Latchininsky, University of Wyoming

Grasshopper outbreaks can financially ruin ranches. Rangeland forage has low value per unit area but if you depend on it to feed your livestock, and can't afford to replace it, you need to protect it. The grasshopper species that unpredictably outbreak and outcompete livestock for forage are an important part of the native ecosystem and shouldn't be extirpated. Many years of field testing was carried out to determine RAATs tactics that reduce grasshopper population densities below the economic injury level. Extensive educational efforts to get RAATs put into practice by USDA-APHIS-PPQ, ranchers, and pesticide companies was also necessary. The effort paid off in 2010 in Wyoming.

1:39 11.3 The Sisyphean task of grasshopper management: exploring new frontiers and revisiting old ones, Derek A. Woller, derek.a.woller@aphis.usda.gov, Rangeland Grasshopper and Mormon Cricket Management Team, USDA APHIS-PPQ-S&T-CPHST Phoenix Lab, Phoenix, AZ; Larry E. Jech, K. Chris Reuter, Lonnie R. Black, USDA APHIS-PPQ-S&T-CPHST Phoenix Lab

Grasshopper management on the rangelands of the western U.S. can be summarized as a Sisyphean task because of complexity. This is due to high numbers of species that often exist in a given region, threat of outbreak that several of these species present, difficulties of monitoring for such outbreaks, and a dwindling chemical arsenal available for adequate control. Thus, the need to explore new frontiers, such as surveying via unmanned aerial systems and field-testing new generic formulations of proven insecticides, as well as revisiting old frontiers, like biopesticides (e.g., fungal pathogens) and continuing assessments of proven insecticides in novel ways.

1:51 11.4 Linking land use and the nutritional ecology of locusts: the case of the Senegalese locust (*Oedaleus senegalensis*), Marion Le Gall, marionlegall314@gmail.com, Julie Ann Wrigley Global Institute of Sustainability, Arizona State University, Tempe, AZ

Locusts are grasshoppers that can form massive migrating swarms and devastate food security. Our research team uncovered links among agricultural practices, plant nutrient content, and locust physiology and behavior. These findings created new opportunities to account for these coupled natural-human system linkages and develop new, sustainable strategies to understand and manage locust outbreaks. Drawing examples from our research in Senegal, I will discuss how nutritional ecology and the Geometric Framework for nutrition can be powerful approaches to 1) study the feeding behavior and performance of generalist herbivores and 2) develop sustainable control methods for locusts and other herbivorous pests.

2:03 11.5 Integrating large-scale pesticide application into IPM, Chris Adriaansen, chris.adriaansen@agriculture.gov.au, Australian Plague Locust Commission, Australia

Is it possible to incorporate large-scale aerial application of insecticides into rangelands IPM? Experience in locust control in Australia, where pesticides may be applied to over half a million acres in a season, shows that managing the timing, concentration, volume and pattern of chemical use not only achieves effective and efficient pest control but does so without significant off-target impact.

2:15 11.6 Integrated management of locusts and grasshoppers, Christiaan Kooyman, christiaan.kooyman@elephantvert.ch, Eléphant Vert SA, Nanyuki, Kenya

Locusts and grasshoppers have been controlled with chemical pesticides for almost 100 years. Because of the speed at which outbreaks can occur, integrated pest management as applied to other pests has eluded those in charge of control campaigns. The closest that could pass as IPM is the practice of preventive control. However, even this practice uses chemical pesticides. This could change now that biological insecticides

based on the entomopathogenic fungus *Metarhizium acridum* have been shown to be as effective as chemical ones if given enough time. The latest product has now been successfully field-tested in six countries in Africa and Central Asia.

2:27 11.7 A new entomopathogenic fungus, *Aspergillus oryae*, and its potential in locust control, Zhang Long, locust@cau.edu.cn, Department of Entomology, China Agricultural University, Beijing, China

Locusts and grasshoppers are serious economic pests on rangeland, and controlled widely by chemical insecticides which rise environmental pollution, resistance to chemicals and other negative side-effects. It is necessary to explore alternative controls which including biological control. A locust pathogenic fungus, *Aspergillus oryae*, is identified. The bioassay showed that its median lethal concentrations were 3.31 × 108, 1.72 × 107 and 7.24 × 106 conidia/ml after 10, 13 and 15 days post-inoculation of 3rd instar nymphs, the mortality of locusts reached at 86% on the 15 days after inoculation with 1 × 108 spores/ml. And its spores are easier to massively produce.

12 • Climate Change and Pest Biology

Homeland

The increase in the introduction of new, invasive pests (insects, plant pathogens, and weeds) represents a significant challenge with respect to maintaining both ecological diversity and to prevent new threats to agricultural production. Yet we recognize that human-induced climatic change associated with weather extremes, precipitation, temperature and carbon dioxide is almost certain to extend the range and increase the impact of invasive species. There is an urgent need therefore to assess the vulnerability of managed systems to climate-induced changes in invasive species biology. Vulnerability can be assessed in terms of migration and range expansion, changes in crop and pest interactions, and changes in pest management. In this symposium, we will provide illustrative examples regarding how global climate change and rising carbon dioxide has and will alter the vulnerability of crop systems to invasive species including insects, plant pathogens and weeds. By doing so we hope to provide additional insights not only into pest biology and ongoing threats posed by an uncertain climate but to also begin to address how integrated pest management could adapt to reduce vulnerabilities to future pest threats. This information should be of interest to a wide range of stakeholders, including IPM practitioners, land managers, policy makers, educators and scientists.

Organizers: Fernando E. Vega, Fernando.Vega@ars.usda.gov, Sustainable Perennial Crops Laboratory, United States Department of Agriculture, Agricultural Research Service, Beltsville, MD; Lewis Ziska, Lewis.Ziska@ars.usda.gov, Adaptive Cropping Systems Laboratory, United States Department of Agriculture, Agricultural Research Service, Beltsville, MD

1:15 12.1 Climate change and pests: Monitor, mitigate and manage, Lewis Ziska, Lewis.Ziska@ars.usda.gov, Adaptive Cropping Systems Laboratory, United States Department of Agriculture, Agricultural Research Service, Beltsville, MD

1:30 12.2 Identifying future invaders: Predicting range shifts with climate change, Bethany A. Bradley, bbradley@eco.umass.edu, Department of Environmental Conservation, University of Massachusetts, Amherst, MA

1:45 12.3 Tracking invasive species over time: Lessons learned from 13 years of Early Detection & Distribution Mapping Systems (EDDMapS), Rebekah Wallace, bekahwal@uga.edu, Center for Invasive Species & Ecosystem Health, University of Georgia, Tifton, GA; Joseph LaForest, Chuck Bargeron, Center for Invasive Species & Ecosystem Health, University of Georgia

2:00 12.4 Adapting disease and pest management under climate change: Scenario analysis to develop strategies and quantify uncertainty, Robin Choudhury, ra.choudhury@ufl.edu, Plant Pathology Department, Institute for Sustainable Food Systems, and Emerging Pathogens Institute, University of Florida, Gainesville, FL; Karen Garrett

2:15 12.5 Climate change and coffee, Fernando E. Vega, Fernando.Vega@ars.usda.gov, Sustainable Perennial Crops Laboratory, United States Department of Agriculture, Agricultural Research Service, Beltsville, MD; Lewis Ziska, Adaptive Cropping Systems Laboratory, USDA ARS

13 • Improving Health Outcomes Related to Asthma and Indoor Air Quality through Integrated Pest Management

Fells Point

The Healthy Homes Program at the New York City Department of Health and Mental Hygiene will present on three initiatives that make the case for incorporating integrated pest management services into health care delivery for people with asthma.

A. Reducing Pest Asthma Triggers through Integrated Pest Management Interventions to Improve Child Health Outcomes. The presentation will present the results from a research study evaluating the return on investment of integrating IPM into asthma care delivery with the goal of influencing Medicaid reimbursement and care delivery for children with Asthma.

B. Collaborative Pest and Asthma Trigger Reduction Project in Homes of NYC Children with Asthma. This presentation will focus on a City program demonstrating the sustainable integration of integrated pest management services into care delivery as part of the New York State Medicaid Delivery System Reform Incentive Payment (DSRIP) Program.

C. Pest Enforcement. Using Local Law to Incorporate Integrated Pest Management into Asthma Care Delivery. The presentation will give an overview of the NYC Pest Enforcement Program which uses the local health code to incorporate IPM best practices into asthma care delivery by collaborating with health care providers to improve housing quality and health outcomes for New York City children with asthma.

Organizer: Michael Millican, mmillican@health.yc.gov, Healthy Homes Program, New York City Department of Health and Mental Hygiene, New York, NY

1:15 13.1 Improving Health Outcomes Related to Asthma and Indoor Air Quality through IPM, Michael Millican, mmillican@health.yc.gov, Healthy Homes Program, New York City Department of Health and Mental Hygiene, New York, NY

14 • The New IPM: Where Is Crop Protection Taking Us?

Federal Hill

Crop production and pest management continues to evolve as new technology and the world's population explodes. A recent CAST paper, Crop Protection Contributions toward Agricultural Productivity, reviewed current pest management trends and future challenges including pesticide resistant and emerging pest issues. The National IPM Coordinating Committee recently developed a white paper, The State of IPM—2016, that summarizes input from the state-based IPM coordinators about the current status of IPM. The National IPM Roadmap, first developed in 2003, is a document produced by the Federal IPM Coordinating Committee that is currently being updated. This session will provide an overview of how current challenges and technologies may alter how IPM is adopted in the real world.

Organizer: Susan Ratcliffe, sratclif@illinois.edu, North Central IPM Center, University of Illinois, Urbana, IL

1:15 14.1 Role of the National IPM Coordinating Committee in the New IPM, Patrick Beauzay, patrick.beauzay@ndsu.edu, National IPM Coordinating Committee, Department of Plant Pathology, North Dakota State University, Fargo, ND

The National IPM Coordinating Committee (NIPMCC) seeks to develop and promote a common vision of IPM practice by promoting proven IPM principles and integrating new science-based pest control strategies. The NIPMCC strives to identify current and future IPM priorities and challenges, promote IPM communication and information exchange through a network of state, regional, federal and private partners, enhance public IPM awareness and education, empower IPM programs to effectively engage and impact diverse stakeholder groups, create visibility for IPM successes at the national level, and improve national capacity to support Extension IPM programming.

1:35 14.2 The Crop Protection Community Increasingly Includes Practitioners and Scientists who Effectively Manage Pests for Agricultural Producers, Norman C. Leppla, ncleppla@ufl.edu, Entomology and Nematology Department, University of Florida, IFAS, Gainesville, FL; Amanda Hodges, Entomology and Nematology Department, University of Florida; Morgan Pinkerton, University of Florida, Gainesville, FL; Sage Thompson, Department of Entomology and Nematology, University of Florida

Agricultural producers expect pest management professionals to rapidly assess plant health problems and provide solutions. Difficult to manage problems often are caused by newly arrived alien invasive species. Pest managers must be able to identify the pests, evaluate their potential to damage crops, and if necessary mitigate their impact by employing technologies that are effective, affordable and environmentally acceptable. If suitable technologies are not available, existing ones are adapted while applied research is being conducted. These pest management actions are facilitated by highly educated and trained IPM practitioners and researchers. Most agricultural producers are not capable of managing novel pests or complex pest problems.

1:55 14.3 Weed IPM: Challenges and Opportunities, Jill Schroeder, Jill.Schroeder@ARS.USDA.GOV, USDA Office of Pest Management Policy, Washington, DC

Weeds can produce tens of thousands to hundreds of thousands of seeds per individual and can remain dormant in the seed bank over time thus creating a continuing problem for farmers. Weed management tactics include cultural practices such as crop rotation and management, mechanical practices including tillage although conservation programs limit tillage as a tactic, biological control (limited options in annual production systems), and herbicides. Integrated weed management programs rely on prevention of new infestations, mapping the weed populations in the fields, and regular scouting to provide the information farmers need to plan and adapt their weed control programs. Challenges that farmers currently face include the problems of increased populations of weeds resistant to herbicides, no new herbicides with a unique mechanism of action to control these weeds, and the economic and production challenges encountered by farmers who want to diversify weed control tactics. Emerging technologies include remote sensing for mapping and site-specific

tillage or herbicide application; genetic technologies to identify weeds, resistance traits in weeds, and new crop traits; tools for reducing weed seed return to the soil seedbank; and new cover crop strategies. Research is needed to understand the biology and population dynamics of weeds as affected by cropping system and environment. Research must continue to develop and demonstrate new technologies and tools, to develop and demonstrate programs to diversify weed management at a local level, and address weed management within the broader context of crop and integrated pest management.

2:15 14.4 The Crop Protection and Biotech Industry Is Driving Change that Improves IPM and Farm Profit Outcomes, Jay Vroom, JVroom@croplifeamerica.org, CropLife America, Washington, DC

The crop protection industry has always been grounded in science-based approaches to helping farmers, including identification and reduction of risk from pests, and pest-related management. The speed and accuracy of our science today is beyond incredible—and now includes synthetic and biologic crop protection tools, biotechnology, gene editing, and ever-growing data collection-management-use. It is fair to say that each of these five technology platform investments by our industry is amazing in itself, but almost always the five combined produce even more outstanding outcomes for farm productivity, profitability, improved environmental outcomes, and of course the assurance we need that consumers are protected. Even more amazing technology is in development! Public policy and public acceptance, on the other hand, are in a much less "advanced state." Integrated Pest Management (IPM) is a key bridge to public policy and public acceptance—and to connecting the practical dots of use of technology. IPM is evolving with the speed of science and technology—our industry needs to engage with all IPM stakeholders like never before to ensure the best possible agriculture that is essential to our industry and which consumers everywhere demand, and desperately need.

15 • Getting the Most out of Drones in the Field

Watertable C

Since 2014, McCain Foods has sought to improve farming with drone technology. This presentation will focus on McCain's efforts with Potatoes New Brunswick and Agriculture and Agri-Food Canada using drone imagery to increase yields. McCain agronomist Tommy Dixon and CCA Dennis Bowman will also share their work with drones to develop better ways of mapping the variability in plant growth and yield and overcoming yield limitations.

Organizer: Christian Steponitis, csteponitis@ipminstitute.org, IPM Institute of North America, Madison, WI

1:15 15.1 McCain Foods' Use of Drone Imagery to Increase Yields, Tommy J. Dixon, tom.dixon@mccain.ca, McCain Foods, Florenceville-Bristol, NB, Canada

2:00 15.2 Using Drones in the Field, Dennis Bowman, ndbowman@illinois.edu, Crop Sciences Research and Education Center, University of Illinois Extension, Urbana, IL

16 • Bee-Friendly Reaches Major Retailers of Ornamentals: The Industry Adapts

Baltimore B

Consumer concern about pesticides in agriculture is a consistent theme driving integrated pest management and market segmentation. Traditionally, consumers have expressed their preference through the purchase of organic or local foods. More recently, interest in the pollinator effects of growing practices used for the production of ornamental plants has escalated. Consumers are learning that neonicotinoid residues are persistent, can be picked up by bees in pollen and nectar, and are linked to bee health problems. Consumers are asking for ornamental plants that won't adversely impact bees in their gardens. These concerns have influenced the nursery and greenhouse industry with such large retailers as Home Depot, Costco, Walmart, and True Value having all committed to phase out or discourage the sale of plants grown with neonicotinoids.

In this panel session, we convene researchers together with representatives from the ornamental plant industry to discuss the trends toward pollinator-friendly plants, and the industry response. We'll explore questions such as: Are pesticide residues in ornamental plants a real concern? What qualities are customers demanding and how are retailers responding? Is the industry adopting non-chemical alternatives or switching to non-systemic insecticides? Is the entire supply chain changing? What marketing mechanisms are consumers responding to? What is the role of labeling and education? What lessons can be gained from the organic industry? How are growers making a transition? What kinds of propagation and distribution models are available? Are investments paying off? Are certification programs useful?

Organizer: Sharon Selvaggio, sselvaggio@pesticide.org, Northwest Center for Alternatives to Pesticides, Eugene, OR

3:00 16.1 Public concern over bees buzzes into the ornamental plant industry, Sharon Selvaggio, sselvaggio@pesticide.org, Northwest Center for Alternatives to Pesticides, Eugene, OR

Ms. Selvaggio will discuss recent announcements by big box retailers stores to eliminate or phase out the sale of neonicotinoid-treated plants, as well as reports in industry publications that ornamental plant growers are voluntarily moving away

from neonicotinoids. Ms. Selvaggio will also facilitate a panel discussion amongst the other participants, discussing recent research on pollen and nectar pesticide residues and consumer labeling preferences, and the responses of the retail and wholesale sectors to the bee health issue.

3:05 16.2 Studies on neonicotinoid and pymetrozine residues in greenhouse plants, Vera Krischik, krisc001@umn.edu, Department of Entomology, University of Minnesota, St. Paul, MN

Pesticide residues in landscape plants remaining from greenhouse treatments merit research. Imidacloprid (Merit) residues in pollen of *Ruellia* at 5 wks (267 ppb) decreased 50% by 10 wks (125 ppb); *Calibrochoa* at 5 wks (492 ppb) decreased 80% by 10 wks (96 ppb); and dinotefuran (Safari) residue at 5 wks (748 ppb) decreased 88% by 10 wks (96 ppb). These levels may alter survival or behavior in bees. Pymetrozine (Endeavor) residue at 5 wks (126 ppb; 1/9) decreased 100% by 10 wks. These data support multiple previous reports showing pesticide residues in ornamental plant pollen and nectar.

3:10 16.3 Investigating Effects of Neonicotinoid Labels on Consumer Preferences and Willingness to Pay for Ornamental Plants, Hayk Khachatryan, hayk@ufl.edu, Food and Resource Economics Department, University of Florida, Apopka, FL

Mr. Khachatryan's research focuses on consumers' preferences and willingness to pay for pollinator-friendly plants, relevant plant attributes, and sustainable production practices. His discussion will focus on how pollinator-friendly labels and neonicotinoid insecticide related information influences end consumers' perceptions, preferences and final demand. He will also talk about consumers' misperceptions, awareness of neonicotinoid pesticides, and their perceptions of production methods. This information is applicable to growers, landscapers and retailers who are interested in pollinator-related attribute options to add value to their product lines.

3:15 16.4 A Retailer's Experience: Responding to our Customers, Gilliann Rodgers, gilliann@potomacgardencenter.com, Potomac Garden Center, North Potomac, MD

Ms. Rodgers will discuss her experience as a nursery manager in adapting to current customer demand; how she screens and selects material from wholesalers, and how her garden center informs and educates customers.

3:20 16.5 A Wholesaler's Perspective on Using Less Neonicotinoids, Bruce Coleman, BruceC@woodburnnursery.com, Woodburn Nursery and Azaleas, Woodburn, OR

Woodburn Nursery and Azaleas, based in Woodburn, Oregon, grows annual baskets/planters, floral azaleas, and a wide range of other woody ornamentals. Our customers continuously ask for plants produced sustainably. We use solar panels, recycle water runoff and plastic pots, and lower pesticide usage. Recently, we have eliminated neonicotinoids on select crops. By using beneficial insects on our crops we are reduce pesticide usage. We recently built a 1,600 square foot beneficial insect rearing facility. When we do need to use pesticides we are careful to use low toxicity products that are proven not to disrupt the existing beneficial insect program.

3:25 16.6 Panel Discussion

17 • Biological Control—A Sustainable Approach in the IPM Toolkit

Guilford

Biological control is just one component of an integrated pest management program, but it can be a long term sustainable technique. Presenters will give details of current research and IPM programs that emphasize biological control. Presenters will discuss both insects, and weeds, focusing on pests of pastures, forests, and natural landscapes. The symposium will include biocontrol programs of the following pests: Emerald ash borer, lily leaf beetle, mile-a-minute, and invasive swallow-worts.

Organizer: Donna Ellis, donna.ellis@uconn.edu, Plant Science & Landscape Architecture, University of Connecticut, Storrs, CT; Lisa Tewksbury, lisat@uri.edu, Plant Science & Entomology, University of Rhode Island, Kingston, RI

3:00 17.1 Biocontrol of Wheat Insect Pests in North Dakota, Janet Knodel, janet.knodel@ndsu.edu, Entomology, North Dakota State University, Fargo, ND; Patrick Beauzay, North Dakota State University

Wheat midge, (Géhin) (Diptera: Cecidomyiidae), and wheat stem sawfly, *Cephus cintus* Norton (Hymenoptera: Cephidae), are economic pests of wheat, *Triticum aestivum* L. in North America. The larval stage of both insects cause significant injury to wheat. Crop losses from these insect pests have been estimated in excess of $50 million to North Dakota wheat production during outbreak periods. The status of parasitoids attacking wheat midge and wheat stem sawfly will be reviewed for North Dakota.

3:20 17.2 Mile-a-Minute Weed: Weevils to the Rescue, Donna Ellis, donna.ellis@uconn.edu, Plant Science & Landscape Architecture, University of Connecticut, Storrs, CT

Mile-a-minute weed (*Persicaria perfoliata*) is a highly invasive annual found in the eastern U.S. Since it was first confirmed in Connecticut in 1997, mile-a-minute has spread to 50 municipalities in the state. It outcompetes and outgrows native species, causing ecological and economic harm. The biological control agent *Rhinoncomimus latipes* is a specialist on mile-a-minute as its host plant and has shown minimal impacts on non-target species. The integrated management of mile-a-minute weed is

a collaborative effort between the University of Connecticut and the Connecticut Agricultural Experiment Station, involving multiple partnerships with local, state, regional, and federal stakeholders.

3:40 17.3 Biological Control of Lily Leaf Beetle with Multi-site Releases in New York State, Brian Eshenaur, bce1@cornell.edu, Cooperative Extension, Cornell University, Rochester, NY

Asiatic lily plantings have been devastated in many areas in the Northeastern US due to the invasive Lily Leaf Beetle (*Lilioceris lilii*). Management success has been achieved with parasitoid releases centered out of Rhode Island. This presentation highlights a collaborative effort between biocontrol experts, integrated pest management staff and field educators to establish the beneficial parasitoids in locations across NY state. The project steps, successes and path forward will be highlighted.

4:00 17.4 Swallow-wort Biocontrol and IPM: At the starting line!, Lisa Tewksbury, lisat@uri.edu, Plant Science & Entomology, University of Rhode Island, Kingston, RI

Black and pale swallow-wort (*Vincetoxicum nigrum* and *V. rossicum*) are invasive plants in Canada and the Northeast US. A biological control program for swallow-worts, begun in 2005, focused on a leaf-feeding caterpillar (*Hypena opulenta*) as the first biological control agent. This species is host specific to *Vincetoxicum* spp. and adults and larvae were first released in Canada in in 2014. In 2017 the USDA approved a permit for release in the US and we are now at the starting line for integration of biological control into current management programs for swallow-worts.

18 • Managing the Former Allopatric *Helicoverpa zea* and *H. armigera* in the Americas: Experience and Challenges Going Forward

Homeland

Corn earworm (*Helicoverpa zea*) and old world bollworm (*H. armigera*) are originated from a common ancestor, geographically isolated, and defined as allopatric species. Both species are economic pests and have a preference to feed on plant reproductive tissues, often causing damage in several economic crops, such as cotton, soybean, corn, tomato, etc. Corn earworm is only present in the American continents. Old world bollworm has historically been reported from Asia, Africa, Europe and Australia, and during the 2012/2013 crop season was detected for the first time in Brazil. Since then, publications have reported old world bollworm in other countries in the Americas, such as Argentina, Paraguay and Uruguay. In The U.S., three old world bollworm moths were collected in Florida in 2015. This session will review IPM/IRM concerns and solutions for corn earworm in the Corn Belt and in Cotton Belt in the U.S., and the management have been adopt for old world bollworm in South America. In addition, this session will discuss the recent scenario of these two former allopatric species cohabiting in the Americans, including the interaction between the two species and the relevance for integrated pest management and insect resistance management.

Organizers: Silvana Paula-Moraes, paula.moraes@ufl.edu, West Florida University of Florida/Entomology & Nematology Department, University of Florida, Jay, FL; William D. Hutchison, hutch002@umn.edu, Department of Entomology, University of Minnesota, St. Paul, MN

3:00 18.1 IPM and IRM in field crops in a scenario of *Helicoverpa armigera* and *Helicoverpa zea,* Silvana Paula-Moraes, paula.moraes@ufl.edu, West Florida University of Florida/Entomology & Nematology Department, University of Florida, Jay, FL

Helicoverpa zea and *H. armigera* originated from a common ancestor, geographically isolated, and are defined as allopatric species. Both species have a preference to feed on plant reproductive tissues, often causing damage in several economic crops. *Helicoverpa zea* is only present in the American continents and *H. armigera* was reported for the first time in Brazil in 2013. Since then, *H. armigera* has spread in the Americas. The recent scenario of these two former allopatric species cohabiting in the Americans will be discussed, including the interaction between the two species and the relevance for IPM and IRM.

3:20 18.2 Old World Bollworm in North America: Tracking Introductions and Assessing the Risk, William D. Hutchison, hutch002@umn.edu, Department of Entomology, University of Minnesota, St. Paul, MN; Todd Gilligan, USDA-APHIS, Ft. Collins, CO; Silvana Paula-Moraes, West Florida Research and Education Center, University of Florida, Jay, FL; Greg Sword, Texas A&M University, College Station, TX

Pheromone traps continue to be used for detection of *H. armigera* moths, with focused monitoring in Puerto Rico and throughout the U.S. via USDA-APHIS and collaborating State Departments of Agric. The morphological identification via male genitalia is time consuming. At Texas A&M a high-throughput DNA sequencing assay for detection of *H. armigera* in bulk moth trap samples was developed using the Illumina MiSeq platform. This high-throughput assay is currently being evaluated on a MinION portable DNA sequencer to enable the development of more rapid and deployable assays for real time detection of invasive *H. armigera* in the field.

3:40 18.3 *Helicoverpa armigera* in South America: Identification, timeline of the occurrence and hybridization with *H. zea,* Daniel R. Sosa-Gómez,

daniel.sosa-gomez@embrapa.br, Embrapa Soja, Londrina, PR, Brazil; Alexandre Specht, Embrapa Cerrados, Planaltina, DF, Brazil; Silvana Paula-Moraes, West Florida Research and Education Center, University of Florida, Jay, FL

Helicoverpa armigera was first detected in Brazil during their peak of high densities in 2012/ 2013, after unusual damages on several crops. Once its occurrence in Brazil caught the attention, entomologists from neighbor countries carried out surveys, and after a short time, it was found that *H. armigera* was present in other South America countries. Consequently, the main concerns were related to their distribution, pest management, and how could be the interaction with local populations of a close related species, such as *H. zea*. Implications of the presence of *H. armigera* in South America and their interactions will be discussed.

4:00 18.4 Managing *Bt* resistant *Helicoverpa zea* in the southern US, Dominic Reisig, ddreisig@ncsu.edu, Department of Entomology and Plant Pathology, North Carolina State University, Plymouth, NC

Plant incorporated *Bt* toxins have successfully managed many lepidopteran pests in the US for over 20 years. One species, *Helicoverpa zea*, has developed resistance to the Cry toxins in both cotton and maize in the southern US. This presentation will detail the impact of this resistance on cotton and maize IPM, changes in management resulting from this resistance and will also focus on ways to delay the development of resistance of other plant incorporated *Bt* toxins, such as vegetative insecticidal protein.

19 • Pest Management and Indoor Allergen Reduction in Low Income Housing

Fells Point

The U.S. Department of Housing and Urban Development (HUD) funds research to eliminate significant obstacles to the implementation of Integrated Pest Management (IPM) in low-income housing. Grantees conduct research on various aspects of residential pest control that can be used to improve IPM for cockroach and bed bug control. By eliminating infestations, IPM reduces exposure to asthma triggers and pathogens from roaches and mice, often resulting in improved asthma control. HUD's ultimate goal is to improve the health and quality of life of residents and reduce the financial burden on housing providers.

The impact of uncontrolled cockroach and bed bug infestations on residents of low-income housing is significant. Poor pest control can be due to multiple factors, including inadequate housekeeping by some residents, poor choice of control strategies by housing managers and pest control operators, and ineffective and restrictive pest control contracts. Insecticide resistance in cockroach and bed bug populations also continues to be a significant barrier to effective pest interventions. In this session, three HUD research grantees present findings that can improve IPM in federally assisted housing. Dr. Schal will discuss the relative efficacy of pest control tactics and the roles of cockroaches and bed bugs in disseminating microorganisms in home environment. Dr. Scharf will present research focused on the development of effective resistance management strategies for cockroaches. Dr. Wang will present the findings from an assessment of a bed bug IPM program implemented in the properties of two public housing authorities in New Jersey.

Organizer: Rachel M. Riley, Rachel.M.Riley@hud.gov, U.S. Department of Housing & Urban Development, Washington, DC

3:00 19.1 Interventions for Reduction of Cockroaches, Allergens and Associated Microorganisms in the Home Environment, Coby Schal, coby_schal@ncsu.edu, North Carolina State University, Raleigh, NC

Cockroaches pose significant challenges to human health, especially in affordable housing where resources needed to implement IPM are scarce. Significant barriers to effective pest interventions also include inadequate house-keeping, poor choice of control strategies by housing managers, residents and pest control technicians, ineffective and restrictive pest control contracts, and extensive insecticide resistance. This presentation will summarize several in-home interventions to eliminate cockroaches and the allergens they produce. Interventions included pest elimination with various approaches, extensive cleaning, resident education, and targeted placement of reduced-risk gel baits. The effects of the interventions on the environmental microbiome will also be discussed.

3:25 19.2 Resistance assessment for making pesticide and IPM decisions, Michael Scharf, mscharf@purdue.edu, Purdue University, West Lafayette, IN

This talk will cover new insights from HUD sponsored research on managing cockroaches and associated allergen loads in public housing. Specific topics to be covered will include insecticide resistance monitoring, calibrating monitoring results against field control efforts, and how/when to integrate diverse PM approaches in resistance management programs. The talk will emphasize applied concepts that are of value to both researchers/academics and practitioners.

3:50 19.3 Implementation and evaluation of community-based IPM programs for bed bug management, Changlu Wang, changlu.wang@rutgers.edu, Department of Entomology, Rutgers University, New Brunswick, NJ

Low-income housing in the U.S. often suffer high prevalence of bed bug infestations. U.S. HUD sponsored research on implementation of bed bug integrated pest management (IPM) programs show that IPM programs were more effective in

reducing bed bug infestations than traditional pest control services, but many factors contributed to the lower than desired level of reduction in infestation rate.

20 • Novel Approaches to IPM Extension: Transferring Learning across Contexts

Federal Hill

Gaining knowledge about adult education theory and program design methods can greatly assist the design and impact IPM education. This session is an opportunity for Extension faculty and others educators to gain knowledge on novel approaches that your peers are successfully employing to increase IPM knowledge and implementation. This includes stakeholder engagement to set and align priorities, the translation of data into actionable decision-support systems, and effective methods of teaching and learning for skill building.

The panel will provide insights into their unique processes and offer transferrable IPM education design principles for you to build into your existing programs. The time for discussion will allow the group to delve deeper into specific areas of interest. There is much to be gained from increasing your knowledge of adult learners and how to better build their confidence in incorporating new data and skills in decision making. We rarely cover how we carry out Extension education, and this session aims to share effective approaches from three contrasting programs that have had significant impacts on IPM adoption.

Organizer: Mary L. Halbleib, mary.halbleib@oregonstate.edu, Integrated Plant Protection Center, Oregon State University, Corvallis, OR

3:00 20.1 Panel Discussion, Paul C. Jepson, paul.jepson@oregonstate.edu, Integrated Plant Protection Center, Oregon State University, Corvallis, OR; Al Fournier, Fournier@cals.arizona.edu, Arizona Pest Management Center, University of Arizona, Maricopa, AZ; Peter Ellsworth, peterell@cals.arizona.edu, Arizona Pest Management Center, University of Arizona, Maricopa, AZ; Neil McRoberts, nmcr01@gmail.com, Center for Environmental Policy and Behavior, University California Davis, Davis, CA; Mary L. Halbleib, mary.halbleib@oregonstate.edu, Integrated Plant Protection Center, Oregon State University, Corvallis, OR

21 • Biopesticide Technology: Science and Challenges

Baltimore A

The Western Integrated Pest Management Center and the Western Unit of the Interregional Research Project #4 (IR-4) are regional programs funded by the United States Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA). Both programs address pest-management. The IR-4 project focuses on registration of pesticides for minor uses—uses on minor crops, specialty crops, and minor uses on larger-acreage crops. The Regional IPM Centers promote adoption of IPM to reduce the risks of pests and pest-management practices. USDA-NIFA directed the Regional IPM Centers and the IR-4 programs to work collaboratively to address pest-management issues. This mini symposium is one of the collaborative projects.

The IR-4 program held its State Liason and Commodity Liason respresentative meeting in Fort Collins, Colorado in April of 2017. At that meeting, speakers presented on the current state of the biopesticide industry, including updates on insect, nematode, plant disease and weed management. The Center and the IR-4 program decided that the meeting structure and topics covered would be highly relevant to the IPM Symposium because the survey of Symposium participants from previous years showed that biopesticides is a priority interest. A subset of the speakers from the IR-4 Biopesticide Workshop has been assembled to present in the mini symposium.

Organizers: Matt Baur, mebaur@ucanr.edu, Western IPM Center, Davis, CA; Amanda Crump, acrump@ucanr.edu, Western IPM Center, Davis, CA; Rebecca Sisco, rsisco@ucdavis.edu, Western IR-4 Project, Davis, CA; Michael Horak, mjhorak@ucdavis.edu, Western IR-4 Project, Davis, CA

8:30 21.1 Development of strategic biological control combinations for control of *Sclerotinia sclerotiorum* on oilseed rape, Dan Roberts, dan.roberts@ars.usda.gov, USDA-ARS, Sustainable Agricultural Systems Laboratory, Beltsville, MD; Xiaojia Hu, Oil Crops Research Institute, Chinese Academy of Agricultural Sciences, Wuhan, China; Dilip K. Lakshman, USDA-ARS, Sustainable Agricultural Systems Laboratory, Beltsville, MD

Sclerotinia sclerotiorum is an economically important soil-borne pathogen of oilseed rape which can cause yield losses ranging from 20 to 80% on this crop. Biological control measures are being developed for this pathogen as chemical pesticides, traditionally used for control, are losing effectiveness due to pathogen resistance and are hazardous to humans and the environment. Toward this end, *Bacillus subtilis* BY-2 and Tu-100 and *B. megaterium* A6 were isolated from different environments and demonstrated to control *S. sclerotiorum* on oilseed rape when applied individually as seed treatments or foliar sprays at flowering. These isolates were also applied in various combinations as seed treatments in field trials conducted at four locations with different soils. Incremental reductions in disease incidence were obtained with increasing number of isolates in the seed treatment preparation. The mycoparasites *Aspergillus aceleatus* Asp-4 and *Trichoderma* sp. Tri-1 were shown to control this pathogen on oilseed rape when sprayed onto the soil prior to sowing. *In vitro* experiments as well as field experiments indicated that control was due to a

reduction in germination of sclerotia of this pathogen. Tri-1 applied in combination with reduced rates of pesticide provided control of this pathogen equivalent to the treatment containing the recommended rate of pesticide. Thus, there is potential to apply biological control treatments in strategic combinations of seed treatments and soil sprays with mycoparasites for sustainable control of *S. sclerotiorum* on oilseed rape.

9:00 21.2 *Bacillus* Products for Disease Control, Denise Manker, denise.manker@bayer.com, Bayer, Sacramento, CA

Here we present information about *Bacillus* products that are currently available in the marketplace for disease control. The talk will cover the different *Bacillus* strains currently in use and their utility in greenhouse and ornamental situations, crop protection, and their use as seed treatments. The talk will cover the mode of action of these products, resistance management, environmental and human health impacts and best use practices.

9:30 21.3 Post-Emergent "Organic" or "Non-synthetic" Herbicides, Cheryl Wilen, cawilen@ucanr.edu, UC ANR, San Diego, CA

The presentation focuses on postemergence contact herbicides that are organic or "non-conventional" but not microbial. The presentation will discuss the current products available, their modes of action, targets and best use practices, and efficacy. The talk will also cover the economics associated with the use of the products discussed.

10:15 21.4 Live Microbial Bioinsecticides, Mike Dimock, mdimock@certisusa.com, Certis, Columbia, MD

Here we will cover live microbial bioinsecticides currently registered for use and commercially available in the US including entomopathogenic fungi and baculoviruses. The talk will cover target pests, modes of action, environmental and human health aspects, best use practices, and efficacy.

10:45 21.5 Phighting Phire Blight with Phage, Julianne Grose, grosejulianne@gmail.com, BYU, Provo, UT

This presentation covers the use of bacteriophages to control plant pathogens. We will discuss the basic biology of bacteriophages and how they affect their host, the history of bacteriophage use, and best current practices. The focus will be the specific example of fire blight control using bacteriophages.

11:15 21.6 Biopesticides for Vegetable Disease Management, Sally Miller, miller.769@osu.edu, Ohio State University, Columbus, OH

Here we discuss the use of biopesticides for vegetable disease management including the reasons for using biopesticides in vegetable production, efficacy and specific disease targets for control. The talk also covers various techniques for improving biopesticide efficacy.

22 • *Drosophila suzukii* Management: What Have Researchers from Asia, Europe, and North America Been Spotting?

Baltimore B

Over the past 9 years, the spotted wing drosophila (SWD), *Drosophila suzukii*, has expanded from its native range in Asia, and invaded temperate areas of North and South America, and Europe. This new invasive pest has posed a novel risk on small and soft-skinned fruit such as berries, cherries, and grapes. As an exception rather than the rule within its genus, SWD actively seeks and successfully attacks healthy ripening fruits, characteristics that have been attributed to its unique olfactory system and serrated ovipositor. These features, along with high fecundity, polyphagy, and lack of natural enemies (among others) have contributed to promote SWD to the status of key pest in many invaded areas. As such, it has the potential to completely ruin crops, leading to high economic costs in prevention, management, and yield loss. In the last years, researchers from all over the world have joined forces to better understand the biology of SWD, and to translate research into strategies to manage it. This symposium intends to cover five of the main pillars of IPM: biological, chemical, and cultural control; sterile insect technique and/or transgenic insects; and behavioral and chemical ecology.

Organizers: Cherre DaSilva, cherre.dasilva@oregonstate.edu, Horticulture, Oregon State University, Corvallis, OR; Dalila Rendon, dalila.rendon@oregonstate.edu, Horticulture, Oregon State University, Hood River, OR; Vaughn Walton, vaughn.walton@oregonstate.edu, Horticulture, Oregon State University, Corvallis, OR

8:30 22.1 Mulching and irrigation management for cultural control of *Drosophila suzukii,* Dalila Rendon, dalila.rendon@oregonstate.edu, Horticulture, Oregon State University, Hood River, OR; Vaughn Walton, Oregon State University; Kelly Hamby, Arielle Arsenault, University of Maryland; Craig Roubos, Ash Sial, University of Georgia; Phillip Fanning, Steve VanTimmeren, Rufus Isaacs, Michigan State University; Andrew Petran, Mary Rogers, University of Minnesota

We tested how different mulching (black weed mat fabric, wood chips, sawdust, bare soil) and irrigation (drip and overhead sprinkler) systems in blueberries affected the survival of immature *Drosophila suzukii (*SWD). We found that fewer SWD emerge from infested blueberries placed above the mulch compared to below the mulch, and that weed mat fabric can act as a barrier to prevent SWD larvae from pupating under the mulch. There was lower natural infestation in blueberries in weed mat fabric compared to other mulches. Lastly, fewer flies emerged from pupae placed on drip plots compared to sprinkler plots.

8:48 22.2 *Drosophila suzukii* chemical control options facing the current lack of regulated insecticides in Brazil, Felipe Andreazza, felipe.andreazza@ufv.br, Entomology, Universidade Federal de Viçosa, Viçosa, MG, Brazil

Despite the serious importance that several countries have given to the management of *Drosophila suzukii,* there are still no insecticides registered to control this pest in Brazil. Thus in my talk, I am going to demonstrate and discuss our research efforts which aimed not only to provide immediate solutions for growers but also to assess potential future threats for control this pest under Brazilian conditions. For that, among other actions, we are screening the local SWD strains' susceptibilities for commercially available synthetic insecticides as well as for alternative insecticide preparations that do not require registration to be used in Brazil.

9:06 22.3 What do *D. suzukii's* interactions with fungi mean for pest management?, Kelly Hamby, kahamby@umd.edu, Entomology, University of Maryland, College Park, MD

Spotted wing drosophila (SWD) interacts with various fungi during its life cycle. Yeasts provide important food resources for both adults and larvae, impacting development and reproductive output. Fruit rot fungi co-occur with SWD larvae and SWD might influence fruit rot incidence. Fungi can positively or negatively impact SWD, with fungal volatiles attracting or repelling SWD. As we begin to understand the relationships between SWD and fungi, we can improve management of SWD and develop novel sustainable management tactics. For example, SWD attractive fungi could improve SWD monitoring, be used in bait sprays, or be used with RNA interference for pest management.

9:24 22.4 Effect of sugars and physiology on the survivorship of spotted wing drosophila, Siew Bee Tang, sbtang@mardi.gov.my, Horticulture Research Centre, Malaysian Agricultural Research and Development Institute, Serdang, Malaysia; Man-Yeon Choi, USDA ARS Horticultural Crops Research Unit

Searching for non-toxic option to manage or complement existing pest management for spotted wing drosophila (SWD) is important. A series of sucrose/erythritol combinations had been tested on SWD in the laboratory and greenhouse, and showed a possibility of erythritol use as a non-toxic insecticide. Results also showed that erythritol combinations were significantly to reduce both fecundity and survivorship of flies in laboratory and greenhouse. A large amount of erythritol was detected in the hemolymph but extremely low in the frass after 24h ingestion, indicating that erythritol might cause the fly mortality by an excessive physiological osmotic change in the body.

9:42 22.5 Deploying chemical repellents in the field for deterring spotted wing drosophila oviposition, Anna Wallingford, annawllngfrd@gmail.com, Invasive Insect Biocontrol and Behavior, USDA-ARS, Beltsville, MD; Dara Stockton; Dong Cha; Gregory Loeb

Spotted wing drosophila (SWD) lays her eggs in the ripe and ripening fruit of several high value fruit crops. Several effective candidate repellents have been identified as oviposition deterrents for SWD in the lab. However, deployment of volatile chemicals in the field offers several challenges. Here we present our recent work investigating the mechanisms of repellency, potential for habituation to repellent chemicals, and some successes and failures in developing practical methods for deploying two oviposition deterrents (1-octen-3-ol and a novel compound, here named DCX).

23 • Nanotechnology and its Increasing Role in IPM

Guilford

Nanotechnology is a promising field and has offered new strategies in IPM in the recent years through interdisciplinary research in Plant Pathology, Entomology, Horticulture, Agronomy, Chemistry, Toxicology, Engineering and Industry partnerships. The potential benefits of nanotechnology in IPM include advancements in nanomaterials-based pesticides for improved disease and insect management, improving efficacy of pesticides at significantly lower concentrations than conventional pesticides, enhancement of agricultural productivity using encapsulated nanoparticles for slow release of nutrients, and improved uptake of nutrients by plants. The symposium will showcase research from six leading experts in the field of nanotechnology with IPM systems. The future and possibilities of nanotechnology in IPM, the design and development of nanoparticles as bactericides and fungicides, the potential of nanoparticles in insect management, the role of nanoparticle in mineral nutrition to boost disease resistance in plants, an industry presentation on the considerations for commercialization of nanoparticles in agricultural applications, and lastly, a presentation on nanoparticle fate and trophic transfer into food chains.

Organizers and Moderators: Wade H. Elmer, Wade.Elmer@ct.gov, Department of Plant Pathology and Ecology, The Connecticut Agricultural Experiment Station, New Haven, CT; Mathews Paret, paret@ufl.edu, Department of Plant Pathology, University of Florida, Quincy, FL

8:30 23.1 Nanoparticles as bactericides: Current technologies and future possibilities, Mathews Paret, paret@ufl.edu, Department of Plant Pathology, University of Florida, Quincy, FL; Amanda Strayer, Ying-Yu Liao, Jeff Jones, Department of Plant Pathology, University of

Florida, Gainesville, FL; Susannah Wright, Steve Olson, Josh Freeman , North Florida Research and Education Center, University of Florida, Quincy, FL; Swadeshmukul Santra, Mikhaeel Young, NanoScience Technology Center and Burnett School of Biomedical Science, University of Central Florida, Orlando, FL; Ismail Ocsoy, Department of Analytical Chemistry, Faculty of Pharmacy, Erciyes University, Kayseri, Turkey; Devron Averett, EcoActive Surfaces Inc., Pompano Beach, FL; Gary Vallad, Gulf Coast Research and Education Center, University of Florida, Wimauma, FL; Weihong Tan, Center for Research at the Bio/Nano Interface, Department of Chemistry and Shands Cancer Center, University of Florida, Gainesville, FL

The bacterial pathogen *Xanthomonas perforans* is the causal agent of bacterial spot disease of tomato that can cause 20-50% under ideal conditions of disease occurrence in Florida. All strains currently in Florida are tolerant due to the heavy use of copper for the past many decades, and hence commercial copper bactericides are not effective. This presentation will cover the latest advancements in engineered antibacterial nanoparticles including photocatalytic nanoparticles (titanium dioxide doped to zinc and silver), silver-dsDNA-graphene oxide nanomaterial matrix, and copper and magnesium oxide nanomaterials against bacterial spot of tomato, and present current status and future possibilities of these materials.

8:55 23.2 Nanoparticles in Weed Control, Renato Grillo, grillo@dfq.feis.unesp.br, Department of Physics and Chemistry, São Paulo State Univ., Ilha Solteira, SP, Brazil; Leonardo Fernandes Fraceto, São Paulo State University (UNESP)—Department of Environmental Engineering, Sorocaba, SP, Brazil

Herbicides have been used throughout the ages to eradicate weeds. However, the indiscriminate uses of these chemicals may cause problems related to their persistence and mobility in the environment. One interesting solution to minimize the toxic effects of herbicides is based on the development of nanocarriers systems such as polymeric nanoparticles. In this way, the encapsulation of herbicides in nanocarriers could potentially increase the agricultural productivity in order to supply food to the predicted rise in the global population, as well as increase the food security. Also, systems that can control the weeds using small amounts of herbicides, can decrease the adverse impacts of the agricultural practices to the environment and human health. In this way, promising results have been obtained using herbicides and nanotechnology for the weed control in agriculture. Briefly, in this talk, we will show the state of art towards the use of herbicides and nanotechnology aiming the development of systems for use in sustainable agricultural practices.

9:20 23.3 Chitosan/dsRNA nanoparticles to enhance oral RNAi efficiency in insects, Kun Yan Zhu, kzhu@ksu.edu, Department of Entomology, Kansas State University, Manhattan, KS

RNA interference (RNAi) is a sequence-specific post-transcriptional gene silencing mechanism mediated by double-stranded RNA (dsRNA). RNAi has been widely considered as a novel strategy for managing insect pests. However, the lack of effective dsRNA delivery methods is a challenge for RNAi-based pest management. This presentation is to provide examples of using chitosan/dsRNA nanoparticles for oral delivery of dsRNA to suppress the transcript level of target genes in insects under laboratory conditions. We found that using the nanoparticles can enhance RNAi efficiency in certain insect species. Possible mechanisms of such an enhanced RNAi efficiency will be discussed in the talk.

10:15 23.4 The use of nanoparticles (NP) of plant micronutrients to enhance plant growth and suppress disease, Wade H. Elmer, Wade.Elmer@ct.gov, Department of Plant Pathology and Ecology, The Connecticut Agricultural Experiment Station, New Haven, CT; Roberto De La Torre-Roche, Nubia Zuverza-Menaand, Luca Pagna, Chaunxin, Ma, Jason White

Micronutrients, such as Cu, Mn, and Zn, activate enzymes that catalyze defense products against root infecting fungi. When NP of CuO, MnO, or ZnO, were compared to bulked equivalents and grown in soil infested with pathogenic fungi, NP of CuO increased fresh weights by 64%, reduced disease values by 69%, and had 32% more Cu in the roots than control, and were superior to other forms. These NP were sprayed onto the foliage of eggplant transplants and set in field plots infested with wilt fungi. Yields were 34% greeted when treated with NP of CuO than in controls. When foliar sprays of NP of CuO were applied to watermelon plants, their growth, yield, and resistance to wilt disease was improved. NP of CuO were superior to NP of AlO, B, CeO, MnO, NiO, SiO, TiO and ZnO or their bulked forms in suppressing diseases of asparagus, chrysanthemum, eggplant, strawberry, tomato, and watermelon. Field studies with alternative source of Cu found NP of CuO produced the most watermelon yield. Digests of edible flesh found no difference in any of metals, but root digests found 50% more Cu suggesting basipetal movement. Transcriptomic analyses found polyphenol oxidase expression was uploaded in plants exposed to the pathogenic fungi and NP of CuO. Potential mechanisms will be discussed.

10:40 23.5 Nanoparticle Composites for Crop Protection, Swadeshmukul Santra, ssantra@ucf.edu, Department of Chemistry and NanoScience Technology Center, University of Central Florida, Orlando, FL; Mikaeel Young, Ali Ozcan, Parthiban Rajasekaran, University of Central Florida, Orlando, FL; A. Strayer, J. B. Jones, YY.

Liao, University of Florida, Gainesville, FL; Monty E. Myers, Indian River Research and Education Center, University of Florida, Fort Pierce, FL; Evan Johnson, James H. Graham, Citrus Research and Education Center, University of Florida, Lake Alfred, FL; M. L. Paret, North Florida Research and Education Center, University of Florida, Quincy, FL

Copper (Cu) bactericides/fungicides are aggressively used in the agriculture industry in the U.S and worldwide on many crops. There is an increasing concern of Cu accumulation in field soil, Cu leaching potential into the surrounding ecosystem and development of bacterial resistance. Using nanotechnology, it is possible to reduce Cu amount per application without compromising overall efficacy. Moreover, Zn based nanoparticle can be developed for potential use as an alternative to Cu bactericides/fungicides. This presentation will focus on laboratory, greenhouse and field efficacy outcome of several nanoparticle composites, challenges towards developing industrially viable formulations and approaches to minimize regulatory challenges.

11:05 23.6 Nanoparticles in the Environment, Jason C. White, Jason.White@ct.gov, Department of Analytical Chemistry, The Connecticut Agricultural Experiment Station**,** New Haven, CT; J.C. White, R. De La Torre-Roche, C. Ma1, N. Zuverza-Mena, The CT Agricultural Experiment Station; J. Gardea-Torresdey, The University of Texas at El Paso; L. Pagano, The University of Parma

The application of nanomaterials (NM) in agriculture is increasing, including controlled release and targeted delivery of pesticides/nutrients, and the use of sensors to increase efficiency. However, the sustainable use of NM in IPM requires an understanding of the fate and effects of these products in the environment. Our investigations have focused on NM trophic transfer through model food chains, as well as on particle interactions with co-existing contaminants such as heavy metals and pesticides. A selection of this work will be presented, with the goal of conveying the importance of understanding these phenomena prior to sustainably pursuing nano-enabled IPM.

24 • Knowledge and Tools to Combat Western Bean Cutworm: An Emergent and Adaptive Pest in North American Maize

Homeland

The western bean cutworm (WBC) is a destructive pest that can cause severe yield loss in corn and dry beans. In addition to direct yield loss due to feeding on corn ears, WBC can also introduce secondary fungal infections causing additional losses to grain quality. Although WBC infestations have historically been limited to the western Corn Belt, recent range expansion has positioned this pest as a threat to most of the North Central Region and beyond, with economic losses now occurring in Michigan, Indiana, Ohio, New York, and Ontario, in addition to the areas with both historic and current economic infestations in Nebraska, Kansas, and Colorado. Current management tactics are limited, and rely heavily upon transgenic *Bacillus thuringiensis* (*Bt*) technology and/or the use of economic thresholds and chemical insecticides. Only two commercially available *Bt* proteins have any efficacy against WBC, and the performance of Cry1F is currently under question. Farmers, crop consultants, and extension professionals have reported failures of existing control methods, including greater than expected damage to Cry1F corn (in multiple states) and control failures following application of pyrethroid insecticides (in Nebraska). Our symposium seeks to improve understanding of the IPM issues surrounding western bean cutworm and increasing collaborations among multistate research and extension communities by bringing together and sharing knowledge, skills, and tools that will lead to increased adoption of effective IPM practices for WBC. This symposium is an objective of a North Central IPM Center Critical Issues Grant received by Peterson et al. for 2017-2019.

Organizers: Thomas Hunt, thunt2@unl.edu, Department of Entomology, University of Nebraska–Lincoln, Haskell Agricultural Laboratory, Concord, NE; Débora G. Montezano, deiagm@gmail.com, Department of Entomology, University of Nebraska–Lincoln, Lincoln, NE; Julie A. Peterson, julie.peterson@unl.edu, Department of Entomology, University of Nebraska–Lincoln, West Central Research and Extension Center, North Platte, NE; Fred Springborn, springb2@msu.edu, MSU Extension, Michigan State University, Stanton, MI; Katharine A. Swoboda Bhattarai, kswoboda3@unl.edu, Department of Entomology, University of Nebraska–Lincoln, West Central Research and Extension Center, North Platte, NE

8:30 24.1 Western bean cutworm, its movement into the Great Lakes States and impact on corn and dry bean pest management, Fred Springborn, springb2@msu.edu, Michigan State University, MSU Extension, Stanton, MI; Christina D. DiFonzo, Department of Entomology, Michigan State University, East Lansing, MI

Since 2000 Western Bean cutworm has been observed in many areas of the Midwest outside of its historical range in the High Plains. As it has moved across the Upper Midwest it has caused sporadic yield losses to grain corn, and yield and quality losses to dry beans and sweet corn. Established populations are now present in areas of Michigan and surrounding States with damage, to varying degrees, observed annually.

8:50 24.2 Management of western bean cutworm in Ontario, Canada, Jocelyn Smith, jocelyn.smith@uoguelph.ca, University of Guelph Ridgetown Campus, Guelph, ON, Canada; Victor

Limay-Rios, Yasmine Farhan, David Hooker, and Art Schaafsma, University of Guelph Ridgetown Campus, Guelph, ON, Canada

First identified in 2008, western bean cutworm, *Striacosta albicosta* (WBC), has rapidly established as a primary pest for Ontario corn producers. Economic injury has increased since 2010 due to WBC feeding and subsequent mycotoxin contamination of grain. Field-evolved resistance to Cry1F transgenic corn has been documented in this region; therefore, WBC control is primarily based on foliar insecticide use. The association and management of WBC injury and Fusarium mycotoxins will be discussed as well as future resistance and integrated pest management strategies in Ontario.

9:10 24.3 Dynamics of EIL and ET of western bean cutworm as a function of larval survival, corn market value, and management cost, Silvana V. Paula-Moraes, paula.moraes@ufl.edu, Entomology & Nematology Department, West Florida Research and Education Center, Institute of Food and Agricultural Sciences, University of Florida, Jay, FL; Thomas E. Hunt, Department of Entomology, University of Nebraska–Lincoln, Haskell Agricultural Laboratory, Concord, NE; Robert J. Wright, Department of Entomology, University of Nebraska–Lincoln, Lincoln, NE; Antonio R. Moraes Jr., Department of Agriculture Economics, University of Nebraska–Lincoln, Lincoln, NE

Western bean cutworm, *Striacosta albicosta* (Smith) (Lepidoptera: Noctuidae), is a native pest of dry beans (*Phaseolus vulgaris* L.) and corn (*Zea mays* L.). It is distributed in the United States, southern Canada, and has recently been reported in Mexico. The adults typically lay eggs on corn leaves, and in the fourth instar, larvae start colonization of the ear where they feed on kernels. Economic injury levels (EIL) were calculated incorporating western bean cutworm larval survival. The calculations of EIL and ETs are discussed considering Paula-Moraes et al. (2013) and the dynamics of corn price and management cost since 2011.

9:30 24.4 Biological responses of western bean cutworm to chemical and transgenic management, Débora G. Montezano, deiagm@gmail.com, Department of Entomology, University of Nebraska–Lincoln, Lincoln, NE; Thomas E. Hunt, Department of Entomology, University of Nebraska–Lincoln, Haskell Agricultural Laboratory, Concord, NE; Priscila M. Colombo da Luz, Department of Entomology, University of Nebraska–Lincoln, West Central Research and Extension Center, North Platte, NE; Dariane Souza, Department of Entomology, University of Nebraska–Lincoln, Lincoln, NE; Bruno Vieira, Department of Agronomy and Horticulture, University of Nebraska–Lincoln, West Central Research and Extension Center, North Platte, NE; Greg Kruger, Department of Agronomy and Horticulture, University of Nebraska–Lincoln, West Central Research and Extension Center, North Platte, NE; Julie A. Peterson, Department of Entomology, University of Nebraska–Lincoln, West Central Research and Extension Center, North Platte, NE

Western bean cutworm (WBC), *Striacosta albicosta* (Smith) (Lepidoptera: Noctuidae) infestations occur every year in Nebraska and at times can be found in high numbers throughout the country and Canada. Current management practices in Nebraska rely heavily on planting transgenic *Bt* corn or applying treatment with conventional insecticides. In response to reports of the reduced efficacy of these methods we established a baseline susceptibility to bifenthrin, a commonly used pyrethroid and detailed the temporal and morphological parameters of the immature stages of *S. albicosta* feeding on Cry1F, Vip3A, toxins target to WBC, and non-*Bt* maize under controlled conditions.

10:15 24.5 Monitoring Cry1Fa toxin resistance levels among western bean cutworm populations, Brad S. Coates, brad.coates@ars.usda.gov, USDA-ARS, Corn Insects & Crop Genetics Research Unit, Ames, IA; Yangzhou Wang, USDA-ARS, Corn Insects & Crop Genetics Research Unit, Ames, IA, and Jilin Academy of Agricultural Sciences, Changchun, China; Sarah N. Zukoff, Department of Entomology, Kansas State University, Southwest Research and Extension Center, Garden City, KS; Thomas E. Hunt, Department of Entomology, University of Nebraska–Lincoln, Haskell Agricultural Laboratory, Concord, NE; Julie A. Peterson, Department of Entomology, University of Nebraska–Lincoln, West Central Research and Extension Center, North Platte, NE

The western bean cutworm (WBC), *Striacosta albicosta*, is a destructive crop in regions of North America, and has adapted to feed on *Bacillus thuringiensis* (*Bt*) Cry1Fa toxin expressing transgenic maize. Laboratory bioassays conducted in 2017 estimated a wide geographic distribution and variance in Cry1Fa resistant phenotypes among field-collected WBC, and were unable to achieve effective LC99 estimates at many locations due to high levels of resistance. Additionally, PCR assays results estimated a high prevalence of endemic microsporidia infections across WBC populations. These results are useful for the modulation of current IPM strategies used to control WBC damage to maize.

10:35 24.6 Harnessing the power of predators and parasitoids to incorporate biological control into western bean cutworm IPM, Julie A. Peterson, julie.peterson@unl.edu, Department of Entomology, University of Nebraska–Lincoln,

West Central Research and Extension Center, North Platte, NE; Westen R. Archibald, Department of Entomology, University of Nebraska–Lincoln, West Central Research and Extension Center, North Platte, NE, and Medical Service Corp, US Navy, Norfolk, VA (current affiliation); Jeffrey D. Bradshaw, Department of Entomology, University of Nebraska–Lincoln, Panhandle Research and Extension Center, Scottsbluff, NE; Débora G. Montezano, Department of Entomology, University of Nebraska–Lincoln, Lincoln, NE; Priscila M. Colombo da Luz, Department of Entomology, University of Nebraska–Lincoln, West Central Research and Extension Center, North Platte, NE; Katharine A. Swoboda Bhattarai, Department of Entomology, University of Nebraska–Lincoln, West Central Research and Extension Center, North Platte, NE; Robert J. Wright, Department of Entomology, University of Nebraska–Lincoln, Lincoln, NE

Current management practices for western bean cutworm (WBC), an emerging pest in the United States, rely heavily on transgenic *Bt* proteins and chemical insecticides, which have serious limitations and resistance concerns. To provide alternative control methods and more balanced IPM strategy, biological control of WBC is critical. Field surveys and molecular gut-content analysis in western Nebraska revealed that Hippodamia convergens, *Coleomegilla maculata*, *Orius insidiosus*, Chrysopidae larvae, and spiders are predators of WBC. *Coleomegilla maculata* will readily consume WBC eggs (17/hour) and neonates (7/hour) in the laboratory. The parasitoid wasp *Trichogramma ostriniae* attacks WBC eggs and has potential for augmentative releases.

10:55	24.7	Discussion, Posters, Materials Sharing

25 • School IPM: Sinking Ship or Soaring Success? A Discussion

Fells Point

The use of IPM in sensitive community environments such as schools and childcare facilities has emerged as a priority as our understanding of the benefits of IPM are tracked over time. School IPM now has a wealth of established tools, strategies, and work groups that facilitate the implementation and evaluation of programs across the country. As we look into the future, there is an urgent need to ensure sustainability of existing programs and continued expansion school IPM. Researchers and Extension personnel have always relied upon strong collaborations and combining multiple smaller programs addressing "non-agricultural" pest management to fuel their work. However, the majority of Federal IPM initiatives still focus on agricultural IPM leaving relatively few opportunities that fund community IPM research and Extension. This session will address the current state of school IPM in the United States, with particular focus on the role of legislative measures and sustainability of school IPM.

The session is envisioned as a group discussion with up to six short presentations by selected speakers who will then serve as a question and answer panel. Discussion topics will include 1) the role of legislation in adoption of school IPM, 2) using schools as public health information distribution centers, 3) enforcement agency perspectives on school IPM laws, 4) involvement of county health and other departments in school IPM through kitchen and food service inspections, and 5) specific school pest issues of national importance. The discussion content will be used to develop a consensus article on school IPM.

Organizer: Shaku Nair, nairs@email.arizona.edu, Arizona Pest Management Center, University of Arizona, Maricopa, AZ

8:30	25.1	Welcome and opening remarks, Shaku Nair, nairs@email.arizona.edu, Arizona Pest Management Center, University of Arizona, Maricopa, AZ
8:40	25.2	Twenty years of school IPM in Texas, lessons learned, Janet A. Hurley, jahurley@ag.tamu.edu, Department of Entomology, Texas A&M AgriLife Extension, Dallas, TX
9:00	25.3	Translating the Science of IPM to the Public, Ruth Kerzee, rkerzee@pesticideaction.org, Midwest Pesticide Action Center, Chicago, IL
9:20	25.4	Developing a sustainable statewide School IPM program in Oregon, Tim Stock, tim.stock@oregonstate.edu, Oregon State University, Corvallis, OR
9:40	25.5	Discussion on above topics
10:15	25.6	Role of legislation in adoption of school IPM/ enforcement agency perspectives on school IPM laws, Veronika Carella, veronika.carella@mdcehc.org, Maryland Children's Environmental Health Coalition, Glenwood, MD
10:35	25.7	School IPM Mentorship Program-Utah State, Ryan Davis, ryan.davis@usu.edu, Utah State University Extension, Providence, UT
10:55	25.8	California School Pesticide Use Reporting Database, Eric Denemark, eric.denemark@cdpr.ca.gov, and Ashley Freeman, Ashley.Freeman@cdpr.ca.gov, California Department of Pesticide Regulation, Sacramento, CA

11:15	25.9	Panel discussion, Veronika Carella; Ryan Davis; Eric Denemark; Ashley Freeman; Dawn H. Gouge, University of Arizona; Janet Hurley; Ruth Kerzee; Kathy Murray, Maine Department of Agriculture; Shaku Nair; Tim Stock
11:40	25.10	Concluding remarks, Shaku Nair

26 • Promoting IPM Techniques in State-sanctioned Study Materials for Pesticide Applicator Licensing: Best Practices from the Top Down

Federal Hill

Pesticides are always going to be a part of IPM programs, so pesticide applicators and other decision-makers need to be aware of how effective pesticide use and safety practices fit within an IPM program. In order to promote more robust IPM practices to these audiences, State Lead Agency (SLA) and Pesticide Safety Education Program (PSEP) staff must work together to find ways to incorporate more IPM instruction into study guides provided to early-career pesticide applicators and other pest control professionals. This panel will explore the relationship between SLA interest in the promotion of IPM and efforts by PSEP staff to craft study guides that include more than just the basics of the safe use of pesticides. The development of the new edition of The Safe and Effective Use of Pesticides, California's core study guide for professional pesticide application licensing exams, will serve as an example of how to deliver more information on IPM techniques while maintaining the same or greater amounts of safety information. To further explore best practices in this area, SLA and/or PSEP staff from other states have been invited to share how they work together to produce educational materials that promote both IPM and pesticide safety to professionals early in their careers.

Organizer: Shannah M. Whithaus, smwhithaus@ucanr.edu, UC IPM Pesticide Safety Education Program, University of California, Agriculture and Natural Resources, Davis, CA

8:30	26.1	Panel Discussion, Laurie Gordon, lgordon@oda.state.or.us, Pesticide User Certification & Licensing, Oregon Department of Agriculture, Salem, OR; Dean Herzfeld, deanh@umn.edu, Pesticide Safety & Environmental Education, University of Minnesota Extension, St. Paul, MN; Clarissa Levi, clarissa.levi@state.mn.us, Agronomy & Conservation Program, Minnesota Department of Agriculture, St. Paul, MN; Michael R. Wierda, mwierda@email.arizona.edu, Pesticide Safety Education Program, University of Arizona, Maricopa, AZ

28 • Integrated Tick Management: Community-Wide Action to Address the Global Tick Problem

Watertable AB

The session will increase awareness and implementation among researchers, educators and practitioners of effective ITM practices, present latest research. The session addresses: 1. Effectiveness of ITM practices used by communities, pest management service providers and individuals in reducing the risk of tick populations and tick borne disease (TBD) incidence. 2. Current research projects and knowledge gaps. 3. Opportunities to increase adoption of effective practices. The session aligns with the IPM Symposium's theme Improving Health, Environment and Global Sustainability by focusing on current and developing ITM strategies used to reduce the incidence of tick-borne diseases. Ticks, tick-borne disease rates and geographic ranges continue to expand; increased awareness, more effective practices and greater adoption are needed. ITM combines a variety of methods including habitat modification, personal tick checks after visiting tick habitat, alternate host management and pesticides including biopesticides and treated clothing to maximize effectiveness and reduce impacts on health and environment globally.

Presenters will discuss 1) current research topics such as Host-targeted Control or a Backyard Integrated Tick Management Study, 2) ITM used by pest professionals and 3) Health implications and educating healthcare professionals to recognize cases and promote prevention.

The breakout session will allow participants to split into groups led by experts from research, pest professionals and healthcare. In these sessions participants can apply insights from the previous presentations and present their group's findings in a final 30-minute closing session.

Organizers: Tom Green, ipmworks@ipminstitute.org, IPM Institute of North America, Madison, WI; Frank Laufenberg, flaufenberg@ipminstitute.org, IPM Institute of North America, Madison, WI

8:30	28.1	The Tick Project, Richard Ostfeld, ostfeldr@caryinstitute.org, Cary Institute, Millbrook, NY; Felicia Keesing, Bard College, Centers for Disease Control & Prevention, New York State Department of Health, Dutchess County Department of Behavioral & Community Health
9:15	28.2	USDA-ARS's Areawide Tick IPM Project (2016-2011): Host-targeted control, Andrew Li, Andrew.Li@ARS.USDA.GOV, United States Department of Agriculture, Agriculture Research Service, Beltsville, MD

10:15 28.3 Backyard Integrated Tick Management Study, Neeta Connally, connallyn@wcsu.edu, Western Connecticut State University, Danbury, CT

11:00 28.4 Oral Vaccines for Tick-Borne Diseases, Maria Gomes-Solecki, mgomesso@uthsc.edu, The University of Tennessee Health Science Center, Memphis, TN

1:15 28.5 Integrated Tick Management used by Pest Professionals, Bob Maurais, bob@mainelyticks.com, Mainely Ticks, Wells, ME

1:45 28.6 LymeShield System, Steve Zatechka, steve.zatechka@usbiologic.com, US BIOLOGIC, Memphis, TN

29 • Maintaining IPM Integrity with Invasive Insects

Baltimore B

Established IPM systems often are overlooked in the urgency to combat alien invasive insect pests with frequent and expensive broadcast applications of broad-spectrum insecticides. These well-intentioned efforts can exacerbate rather than mitigate pest problems, increase damage to crops while endangering non-target organisms, and cause the benefits of previously effective IPM tactics to be lost. Reacting to an invasive pest outbreak as a crisis not only puts the infested commodity on a 'pesticide treadmill' but also can lead to secondary pest problems due to the elimination of natural enemies and competitors. A more balanced approach to managing invasive insects would be first to plan for the arrival of an invasive insect as much as possible, modify cultural practices, and develop minimally intrusive insecticidal management tactics. Insecticides should be selective, least disruptive to beneficials, applied with precision methods, and be limited to spot treatments based on scouting. Examples will be presented to stimulate discussion on how to adjust rather than ignore an existing IPM system when a new invasive insect pest is detected. These include the tomato leaf miner or South American tomato moth, Tuta absoluta, and old world bollworm, *Helicoverpa armigera*, that are threatening the U.S. borders and the Asian Citrus Psyllid, *Diaphorina citri*, and brown marmorated stink bug, *Halyomorpha halys*, that have arrived and been addressed.

Organizers: David Owens, owensd@udel.edu, University of Delaware, Newark, DE; Norman C. Leppla, ncleppla@ufl.edu, University of Florida, Gainesville, FL

10:15 29.1 Monitoring and Forecasting the Spread and Management of *Tuta absoluta,* Rangaswamy (Muni) Muniappan, rmuni@vt.edu, IPM Innovation Lab, Virginia Tech, Blacksburg, VA

The South American tomato leafminer, *Tuta absoluta*, was accidentally introduced to Spain in 2007. In the past 10 years it has spread to most of Europe, Africa, Central Asia, and South Asia. Currently it is in the process of invading Southeast Asia. It has also moved northwards from South America to Panama and Costa Rica. The IPM Innovation Lab has conducted 16 workshops and symposia in national, regional, and international gatherings to create awareness on the impending invasion of this pest as well as provide management options. It also has a project to model the spread of this pest around the world. *Tuta absoluta* is a pest of solanaceous crops but it prefers tomato the most. It primarily mines leaves but also can bore into tender shoots and fruits. It is a major quarantine concern in the United States and as a result, regulations have been promulgated to prevent accidental introduction from infested countries. The IPM Innovation Lab has introduced an IPM package in Nepal to manage effectively this pest without the use of chemical pesticides.

10:30 29.2 Old world bollworm, *Helicoverpa armigera*—Preparedness and response for a potential threat to the southeastern U.S., Amanda C. Hodges, achodges@ufl.edu, Entomology and Nematology Department, University of Florida, Gainesville, FL

On an international level, *H. armigera* is considered perhaps one of the most significant agricultural pests in Asia, Europe, Africa, and Australasia. Although the corn earworm, *Helicoverpa zea*, is morphologically similar to H. armigera and commonly detected in the southeastern U.S., *H. armigera* rapidly develops insecticide resistance and is not easily managed. Furthermore, differentiation of the two species requires a complex dissection of male genitalia and current pheromone-based traps attract both species. Concerns related to Helicoverpa species only emerged in Brazil as farmers reported increasing problems with insecticide resistance during the 2011-2012 and 2012-13 growing seasons. On June 17, 2015, the Florida of Department of Agriculture and Consumer Services, Division of Plant Industry announced the detection of one male *H. armigera* during a routine Cooperative Agricultural Pest Survey (CAPS) pheromone trap surveillance. On June 24, 2016, USDA-APHIS-PPQ determined that the Florida detection of *H. armigera* was an isolated regulatory incident. Despite the determination of H. armigera as an isolated regulatory incident, specialists consider opportunities for re-introduction through the natural movement from Puerto Rico or other Caribbean locations to be high. USDA-APHIS-PPQ initiated and funded interagency efforts to diagnose, prepare, and respond to the occurrence of additional *H. armigera* incursions. Current survey efforts for *H. armige*ra in the southeastern U.S. will also be discussed.

10:45 29.3 The California citrus IPM response to the crisis of Asian citrus psyllid as a vector of huanglongbing, Elizabeth E. Grafton-Cardwell, eegraftoncardwell@ucanr.edu, Department of Entomology, University of California, Riverside, CA

The invasive Asian citrus psyllid, *Diaphorina citri*, is the vector of the bacterial pathogen, *Candidatus Liberibacter asiaticus*, that causes huanglongbing (HLB). This disease has devastated Florida citrus in the short time since the arrival of the psyllid in 1998 and the appearance of the disease in 2005. Asian citrus psyllid was first discovered in California in 2008 and HLB first found in 2012. Prior to the arrival of this pest and disease complex, California citrus growers enjoyed a long and successful history of biologically-based IPM. Growers in the southern regions of the state with its mild climate applied few if any insecticides and relied heavily on natural enemies. Biological control in the central San Joaquin Valley was more difficult to achieve because the climate was not as supportive of natural enemies. However, even in that region, growers could successfully manage pests by applying 3-4 carefully timed and chosen insecticides in order to preserve natural enemies. The threat of huanglongbing has dramatically changed the success of biologically-based IPM throughout the state as growers mount an Asian citrus psyllid eradication/suppression program. The goal of the program is to suppress psyllids and slow the spread of huanglongbing until a cure or management tactics for the disease can be found. Much to the dismay of the pest control advisors and growers, the most psyllid-effective insecticides are also the most disruptive of IPM programs. Outlined in this talk are the intense challenges for California citrus IPM and the creative solutions that are evolving.

11:00 29.4 Management of the invasive brown marmorated stink bug in apple orchards using pheromone-based technologies, Tracy Leskey, Tracy.Leskey@ars.usda.gov, USDA-ARS Appalachian Fruit Research Laboratory, Kearneysville, WV; W.R. Morrison, USDA, Agricultural Research Service, Center for Animal Health and Grain Research; B.R. Blaauw, Department of Entomology, University of Georgia; B. D. Short, USDA, Agricultural Research Service, Appalachian Fruit Research Station; K.B. Rice, USDA, Agricultural Research Service, Appalachian Fruit Research Station; A. Acebes-Doria, USDA, Agricultural Research Service, Appalachian Fruit Research Station; A.L. Nielsen, Rutgers Agricultural Research and Extension Center; J.C. Bergh, Virginia Tech, Alson H. Smith, Jr. Agricultural Research and Extension Center; G. Krawczyk, Department of Entomology, Fruit Research and Extension Center, Penn State; Y.-L. Park, Division of Plant & Soil Sciences, West Virginia University; B. Butler, Carroll County Cooperative Extension, University of Maryland; D.W. Weber, USDA-ARS Beltsville Agricultural Research Center; A. Khrimian, USDA-ARS Beltsville Agricultural Research Center

The introduction of *Halyomorpha halys*, the brown marmorated stink bug (BMSB), in the USA has disrupted many established IPM programs for apple throughout the mid-Atlantic region. Following the identification of the *H. halys* pheromone and pheromone synergist as well as effective monitoring trap designs, we developed trap-based treatment thresholds for managing this pest in apple that reduced insecticide inputs by over 40%. We also explored the potential for attract-and-kill (AK) implementation in commercial apple orchards to effectively manage the threat posed by this invasive species. Over two years at farms in NJ, PA, VA, WV and MD, we found that the use of AK (perimeter row apple trees baited with pheromonal stimuli and treated with insecticides weekly) effectively controlled BMSB compared with standard grower practices. At select AK-baited trees, over 10,000 BMSB individuals were killed in two growing seasons, while use of AK reduced the crop area treated with insecticide against BMSB by up to 97%. Using AK had no impact on the natural enemy or secondary pest community over the same period. Further optimization of monitoring traps using clear sticky cards and AK including defining the 'trapping area' of pheromone lures as well as utilizing long-lasting insecticide treated nets as a killing agent have the potential to improve the overall adoptability of this approach by commercial growers.

30 • Tools and Processes for the Transition towards Lower-risk Pesticide Programs in IPM Systems

Federal Hill

The most recent version of the Food and Agriculture Organization's International Code of Conduct on Pesticide Management formally acknowledges the central role of IPM in reducing pesticide risks to better protect human and ecological health and achieve lasting transformation to more sustainable practices. Reducing pesticide risks is also among the goals of the National IPM Roadmap. IPM Extension programs are essential to progress in risk reduction and provide an essential component of risk management by contributing to safe and effective use, and employment of alternatives to pesticides. Successful efforts in hazard elimination and risk reduction must address multiple pathways, including decision-support in pesticide selection to encourage use of low and reduced-risk products, risk mitigation education for higher risk products, and encouraging the phase-out of highly hazardous pesticides in order to best protect human health and safety and preserve ecological services.

The panelists all have direct experience in addressing hazard elimination and risk reduction through research, extension, regulatory processes and marketplace mechanisms, and they represent the main pathways via which risk reduction can

be achieved. All are active in IPM and engage with farmers directly. A group of State IPM Coordinators in the Western USA are partnering in a regional collaborative effort and a representative from this group of over 20 extension educators will also participate in the panel.

The session is intended to inspire positive and practical follow-up by participants, and to enable follow-up in other US regions and countries.

Organizers: Paul Jepson, paul.jepson@oregonstate.edu, Integrated Plant Protection Center, Oregon State University, Corvallis, OR; Katie Murray, katie.murray@oregonstate.edu, Integrated Plant Protection Center, Oregon State University, Corvallis, OR

10:15 30.1 Panel Discussion, Paul Jepson, paul.jepson@oregonstate.edu, Integrated Plant Protection Center, Oregon State University, Corvallis, OR; Bob Nowierski, rnowierski@nifa.usda.gov, USDA, National Institute for Food and Agriculture, Washington, DC; Katie Murray, katie.murray@oregonstate.edu, Integrated Plant Protection Center, Oregon State University, Corvallis, OR; Joe Huesing, jhuesing@usaid.gov, USAID, Bureau for Food Security, Washington, DC

31 • How Growers Can Benefit from Weather Station Networks

Watertable C

Weather is a major factor in crop yields and the spread of disease. By communicating weather forecasts through networks such as the Network for Environment and Weather Applications, growers can save thousands on input reductions and increase yield by preventing unnecessary nutrient runoff. This session will present the benefits of weather network stations and explain how they can save growers time and money.

Organizer: Christian Steponitis, csteponitis@ipminstitute.org, IPM Institute of North America, Madison, WI

10:15 31.1 How growers can benefit from weather station networks, Dan Olmstead, dlo6@cornell.edu, New York State Agricultural Experiment Station, Cornell University CALS, NEWA, Geneva, NY

32 • Protecting Pollinators

Baltimore A

Pollinators provide critical ecosystem services and contribute billions in added crop value. However, managed and wild bee populations have been in decline globally. Pesticide exposure has been identified as a major contributing factor impacting bee health. In particular, the pervasive use and impact of systemic neonicotinoid insecticides has been the subject of many controversial debates among researcher, regulators, and stakeholders. The potential effects of fungicides on developing bees and their potential synergistic interactions with other compounds have also become of interest to researchers. Therefore, pest managers are faced with the challenge of balancing effective pest control with maintaining healthy pollinator communities. This symposium session will explore our current understanding of how pesticides, such as neonicotinoids and fungicides, are impacting bee health. We will highlight examples of pollinator-friendly IPM practices and identify ways to implement pollinator conservation in production fields. Presenters will also participate in a panel discussion to discuss bee health issues and how to mitigate pesticide exposures in agroecosystems.

Organizer: Judy Wu-Smart, jwu-smart@unl.edu, Department of Entomology, University of Nebraska–Lincoln, Lincoln, NE

1:15 32.1 An overview of the current health of honey bees and the role interacting key stressors play, Judy Wu-Smart, jwu-smart@unl.edu, Department of Entomology, University of Nebraska–Lincoln, Lincoln, NE

Multiple stressors contribute to the decline of honey bee colonies. These stressors include pests, pathogens, pesticides, malnutrition, and poor management. The ways in which stressors interact with one another obscures our ability to detangle and determine main causes of bee loss. The social behaviors and adaptations employed by honey bees to deal with these stressors further complicates our ability to develop mitigation actions and best management practices. This presentation will review the complexity of interacting stressors on honey bees and how social behaviors in honey bees play an important role in colony health.

1:35 32.2 Pesticide drift from pneumatic planters, a significant downside for seed treatment pesticides, Arthur W. Schaafsma, aschaafs@uoguelph.ca, Department of Plant Agriculture, University of Guelph, Ridgetown, ON, Canada

The use of seed treatment pesticides is controversial in integrated pest management. One of the negative aspects is the unintended exposure of non-targets to dust drift originating from the widespread planting of treated seeds using pneumatic planters. This presentation points out a significant design flaw in North American pneumatic planters that leads to this drift exposure. Since 2013, we have been studying the problem on farms using commercial planters, focusing on neonicotinoid insecticides. We have determined and will discuss the proportion of active ingredient escaping as dust, the mechanical reasons for the escape and potential solutions.

2:00 32.3 Polyethylene wax as a vacuum planter lubricant for dust emission reduction, Ronald L. Reichert, ron.reichert@bayer.com, SeedGrowth Product

Development, Application Technology, Bayer, Crop Science Division, Research Triangle Park, NC

The use of talc, graphite, or talc/graphite planter lubricants by growers in vacuum planters has been a standard recommendation by planter manufactures to improve uniformity of planting. The role of planter lubricants on the amount of dust exhausted during planting has been raised as an issue of concern. As a result testing was initiated and it was discovered that the use of a polyethylene wax had the potential to further reduce the amount of dust and active ingredient potentially released during planting beyond that achieved with just a coating/polymer system applied at treatment.

2:25 32.4 Pollinators, Integrated Pest Management and Pesticide Stewardship—Crop Protection Industry, Caydee Savinelli, caydee.savinelli@syngenta.com, Stewardship & Regulatory Policy, Syngenta Crop Protection; LLC, Greensboro, NC; Dick Rogers, Crop Science, Bee Care Center, Bayer U.S. LLC, Durham, NC

The crop protection industry is committed to integrated pest management to optimize environmental protection and provide growers with the tools needed to effectively control pests and maximize yield potential of their crops. Pollinators are a critical part of the agricultural landscape and provide an excellent example of how the industry can mitigate risks through the traditional areas of regulatory science, label mitigation and pesticide stewardship while integrating specific proactive measures to improve honey bee health and establishment of pollinator forage and habitat.

3:00 32.5 Effect of Insecticides, Fungicides and Combinations Applied to Almonds During Bloom on Survival of Honey Bees, Reed M. Johnson, johnson.5005@osu.edu, Department of Entomology, The Ohio State University, Wooster, OH

Pollinating beekeepers have reported observing dead adult bees and dead or malformed brood during and after almond bloom, which are attributed to pesticide exposure. In almonds and other bee-attractive crops "bee safe" insecticides are frequently applied as a tank mix with a fungicide and the consequences of exposure to such combinations are largely untested. The objectives of this study were to test the effects of the most commonly used insecticides (chlorantraniliprole, diflubenzuron, and methoxyfenozide), fungicides (proiconazole, iprodione, and boscalid+pyraclostrobin) applied in combination during almond bloom on honey bee larval development and adult bee survival using laboratory bioassays.

3:25 32.6 What can we learn by measuring field-level fungicide exposure in honey bees during orchard bloom?, Julianna K. Wilson, jkwilson@msu.edu, Department of Entomology, Michigan State University, East Lansing, MI

As lab-based bioassays uncover sub-lethal effects of fungicides on honey bee health, it is important to quantify real-world exposure in crops both dependent on pollination services and fungicide use for disease suppression. Orchards are an attractive floral resource for honey bees and growers rely on honey bees for pollination services. Meanwhile key diseases will infect unprotected plant tissue during bloom if not suppressed by fungicides. This presentation will report on work conducted in tart cherry orchards in Michigan and its implications for honey bee health in this crop. Best practices for balancing disease management and pollinator health will be discussed.

3:50 Panel discussion

33 • The Spread and Management of the South American Tomato Leafminer, *Tuta absoluta*

Baltimore B

The South American tomato leafminer, *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae), a native of South America, is a serious pest of tomato causing up to 80-100% yield losses if no appropriate control measures are taken. Following its accidental introduction to Spain in 2006, *T. absoluta* was recorded throughout Europe and the Mediterranean by 2010. This invasive pest has since spread to the Middle East and North Africa, East and West Africa, and reached India in 2014, Central Asia in 2015, Bangladesh and Nepal in 2016. *T. absolua* is on a trajectory to spread to rest of Asia. It poses a threat of invasion to the United States: (1) it has already spread northwards to Panama and Costa Rica from South America; and (2) through the imported tomatoes from Europe. Commercial growers have mainly relied on chemical control as a primary management tactic for *T. absoluta*. Because of the heavy use of chemical insecticides, this insect has developed resistance to organophosphates, pyrethroids, and others. Pheromone traps are widely used for monitoring and mass trapping. Growers need to implement mass trapping with insecticides or on an area-wide basis to be effective. Several parasitoids and predators of *T. absoluta* have been identified. Augmentative release of predatory mirid bugs, and egg parasitoids have been used. Biopesticides such as *Bacillus thuringiensis*, *Beauveria bassiana*, and neem products are used in an IPM approach. This session will cover the biology, spread, and management of *T. absoluta*.

Organizers: Amer Fayad, afayad@vt.edu, Center for International Research, Education, and Development, Virginia Tech, Blacksburg, VA; Rangaswamy Muniappan, rmuni@vt.edu, Center for International Research, Education, and Development, Virginia Tech, Blacksburg, VA

1:15 33.1 The Biology and spread of *Tuta absoluta,* Rangaswamy Muniappan, rmuni@vt.edu, Center for International Research, Education, and Development, Virginia Tech, Blacksburg, VA

The South American tomato leafminer, *Tutu absoluta*, was accidentally introduced to Spain in 2006 from Chile. Since then it has covered most of Europe, Africa, the Mediterranean, and Central and South Asia. We expect it to spread to some Southeast Asian countries sometime this year. It has also established in Panama and Costa Rica in Central America. It is a pest of mostly solanaceous plants but it prefers tomato the most. It can cause total crop loss in tomato unless timely interventions are taken up. The IPM Innovation Lab has been tracking this pest since 2013 when it invaded Senegal.

1:35 33.2 Tomato leafminer, *Tuta absoluta*, and its management in Nepal, Lalit Sah, lpsah@ideglobal.org, International Development Enterprises iDE Nepal, Kathmandu, Nepal; Mukti Devkota, Luke Colavito, iDE Nepal, Patan, Nepal; Yubraj Dhakal, CEAPRED, Kathmandu, Nepal; Shiva Yendyo, Agricare Nepal Pvt. Ltd, Chitwan, Nepal; GC Yubak, Plant Protection Society of Nepal, Kathmandu, Nepal; Dilli Sharma, Plant Protection Directorate, Kathmandu, Nepal; George Norton, Rangaswamy Muniappan, Virginia Polytechnic Institute and State University, Blacksburg, VA; Edwin Rajotte, Sulav Paudel, Pennsylvania State University, University Park, PA

Tomato is one of the most important vegetable crops for to small-holders in Nepal. The invasive leafminer, *Tuta absoluta*, has become a major pest problem. Its infestation has been reported across polyhouse cultivation in Nepal. It mines tomato leaves and bores into fruits. Most of the tomato growers are unaware of the pest's biology and consequently the management options. In collaboration with the Nepal government and the IPM Innovation Lab, iDE has developed IPM approaches to tackle this pest. iDE employs public-private partnerships to develop smallholder commercial pockets and last mile supply chains to reach farmers with the IPM technologies.

1:55 33.3 Monitoring the Spread and Management of *Tutu absoluta* in Bangladesh, Md Shahadath Hossain, mshahadath67@gmail.com, Horticulture Research Center, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh; Yousuf Mian, Bangladesh Agricultural Research Institute

Since the establishment of *Tuta absoluta* in western India in November 2014, we have been monitoring its possible spread to Bangladesh by setting up pheromone traps at Jessore in the west, and Panchogarh in the north. To our surprise, it showed up in the pheromone traps set up in the Panchagarh District in in May 2016. The pathway of introduction was unknown, as the adjoining regions in India and Nepal to this district were not infested. Currently this pest has spread throughout Bangladesh and we are managing it by setting up pheromone traps and using biological and botanical pesticides.

2:15 33.4 Monitoring the spread of *Tuta absoluta* using a multi-layered network based modeling framework, Abhijin Adiga, abhijin@bi.vt.edu, Biocomplexity Institute, Virginia Tech, Blacksburg, VA

Trade and transport of goods is a primary pathway for the introduction and dispersal of invasive species. Understanding commodity flows remains a challenge due to its complex nature, lack of quality data, and dearth of systematic modeling methods. We propose a generic framework combining robust network-based tools, to model commodity flows, with ecological models and economic impact analyses to provide comprehensive risk assessment for policy makers and risk assessors. We apply these to study *Tuta absoluta*, a pest of tomato, whose rapid invasion of Europe, Asia and Africa in the last decade is widely attributed to international and domestic trade.

34 • IPM Achievement Award Winner Presentations

Homeland

This symposium session will highlight the work of the winners. Dawn Gouge, AZ and Rachid El Aini from the National Institute of Agronomic Research in Morocco received the IPM Practitioner award. International IPM Awards for Excellence went to the Megacopta Working Group, North Central Soybean Entomology Research and Extension Team, and IPM of Late Blight and FFS "farmer field school" Activity Program piloted by the International Potato Center in Lima, Peru. IPM In Recognition are PRISME Consortium of Canada will present on sterile insect release, the European Grapevine Moth Team, CA, and Pest Management University (PMU) in Florida.

Organizers: Janet A. Hurley, jahurley@ag.tamu.edu, Department of Entomology, Texas A&M AgriLife Extension, Dallas, TX; Megha Parajulee, mparajul@ag.tamu.edu, Department of Entomology, Texas A&M AgriLife Research, Lubbock, TX; Shaku Nair, nairs@email.arizona.edu, Department of Entomology, Arizona Pest Management Center, University of Arizona—MAC, Maricopa, AZ

1:15 34.1 The Megacopta Working Group: A Team Approach to Addressing the Challenges of an Invasive Insect Species, Wayne A. Gardner, wgardner@uga.edu, Department of Entomology, University of Georgia, UGA Griffin Campus, Griffin, GA; Phillip M. Roberts, Alton N. Sparks, Jr., Michael D. Toews, Department of Entomology, University of Georgia, UGA Tifton Campus, Tifton, GA; John N. All (retired), Department of Entomology, University of Georgia; G. David Buntin, Daniel R. Suiter,

Department of Entomology, University of Georgia, UGA Griffin Campus, Griffin, GA; Jeremy K. Greene, Clemson University, Edisto Research and Education Center, Blackville, SC; Tracie M. Jenkins (retired), Department of Entomology, University of Georgia; John R. Ruberson, Department of Entomology, Kansas State University, Manhattan, KS; Joe LaForest, Charles Bargeron, Center for Invasive Species and Ecosystem Health, University of Georgia, UGA Tifton Campus, Tifton, GA; Xing Ping Hu, James Langcuster, Auburn University, Auburn, AL

The kudzu bug, *Megacopta cribraria*, was first discovered in North America in October 2009. It was initially recognized as a nuisance pest, but its rapid spread and high populations in soybean in 2010 established it as an agricultural pest. Spread of the insect was monitored and documented to provide valuable predictive alerts. Soybean yield impact by the insect and action thresholds were established. Indigenous generalist predators, parasitoids, and pathogens caused only minimal levels of mortality as initially observed and reported. Science-based information also served as the basis for averting threats by Central American trading partners to cease importation of agricultural commodities from areas of the U.S. infested with kudzu bug.

1:25 34.2 15 Years of Teamwork: The North Central Soybean Entomology Research and Extension Group, Kelley J. Tilmon, tilmon.1@osu.edu, Department of Entomology, Ohio State University, Ohio Agricultural Research and Development Center, Wooster, OH

The North Central Soybean Entomology team, with members in 12 states, has been cooperatively engaged in insect IPM for soybean for over 15 years. The team employs a unique blend of applied and basic sciences (including genomics, plant breeding, ecology, and biological control), along with dedicated extension programming. The team researches and develops integrated soybean insect management strategies and provides recommendations through collaborations with university extension, industry, and soybean commodity boards at the state, regional and national levels. This talk will focus on some of the accomplishments of this long-standing soybean IPM team, and elements that contribute to their strong and continued collaboration.

1:35 34.3 Addressing the human and technical dimensions of potato IPM using farmer field schools (FFS): CIP and partners' experience on potato late blight management, Oscar Ortiz, O.ORTIZ@CGIAR.ORG, International Potato Center (CIP), Lima, Peru; R. Nelson, School of Integrative Plant Science, Cornell University, Ithaca, NY; M. Olanya, USDA-ARS, Eastern Regional Research Center, Wyndmoor, PA; G. Thiele, R. Orrego, W. Pradel, International Potato Center (CIP) Lima, Peru; R. Kakehunzire, Potato Program, National Agricultural Research Organization, Uganda; G. Woldegiorgis, Ethiopian Agricultural Research Organization, Holetta, Ethiopia; J. Gabriel, PROINPA, La Paz, Bolivia; X. Kaiyun, formerly CIP-China, Beijing, China

Since the early 2000's, the International Potato Center team worked with research and development organizations (government and NGO) partners, on potato late blight, working together for the first time, in Bangladesh, China, Ethiopia, Uganda, Bolivia, Ecuador, and Peru, to develop farmer discovery based learning methods, making principles of LB management more visible and understandable for with resistance to the disease. Results indicated that farmers learned new knowledge, assessed new potato clones, and other management options in a participatory way. Adoption was reflected in 32% average increase in potato productivity and income in Peru, and similar changes occurred in the other countries.

1:45 34.4 PRISME Consortium of Canada and sterile insect release, Linda Roberge, lroberge@prisme.ca, PRISME/Phytodata, Sherrington, QC, Canada; Anne-Marie Fortier, afortier@phytodata.ca, Phytodata, Sherrington, QC, Canada; Hervé Van Der Heyden

PRISME Consortium of Canada had a goal to reduce onion maggot populations, the main insect pest in onion crops in Canada. PRISME helped onion growers combat onion maggot and onion blight disease while reducing both pesticide use and crop loss. PRISME launched two programs for onion growers: one using sterile insects for onion maggot and another using spore trapping for onion blight disease. The sterile insect program was so successful that releases have decreased by 90 percent in the last 5 years to only precision treatments. Spore trapping has reduced fungicide use in onions by 35 percent in the last 5 years.

1:55 34.5 European grapevine moth eradication: A collaborative effort, Lucia G. Varela, lgvarela@ucanr.edu, University of California Cooperative Extension (UCCE), Santa Rosa, CA; Walt J. Bentley, UCCE Kearney Agricultural Research and Extension Center, Parlier, CA; Larry J. Bettiga, UCCE, Salinas, CA; Monica L. Cooper, UCCE, Napa, CA; Kent M. Daane, Robert A. Van Steenwyk, Department of Environmental Science Policy and Management, UC Berkeley, CA; Gregory Simmons, USDA-APHIS-PPQ, CPHST California Station, Salinas, CA; Rhonda J. Smith, UCCE, Santa Rosa, CA; Joyce Fox Strand, UC IPM Program, UC Davis, CA; Frank G. Zalom; Department of Entomology and Nematology, UC Davis, CA

The EGVM Team addressed research and extension needs of regulators and the grape industry to mount an eradication campaign. The Team assembled information from overseas

and, within 90 days, a literature review describing current knowledge of life cycle and management was published on the UC IPM Exotic and Invasive Pests webpage. The Team studied the biology and life cycle under California conditions, assisted growers to monitor and control this pest, and addressed regulatory questions regarding detection and spread. The results were used to develop extension and regulatory recommendations on trap location and density, insecticide selection and timing, and handling of winery waste and sanitation measures.

2:05 34.6 Pest Management University (PMU) in Florida, Faith Oi, foi@ufl.edu, Entomology and Nemotology Department, University of Florida, Gainesville, FL

Pest control is a combination of art and science. The vision was to develop an academy where the pest control industry could receive state-of-the-art training in pest biology, control methods, laws, regulations, and Best Management Practices. Pest Management University (PMU) is a cooperative effort between the pest control industry, University of Florida IFAS, and Department of Agriculture Consumer Services. There are over 35,000 members of the pest management community in the State of Florida who need current, practical, curriculum-based training. PMU leads in developing an industry of problem-solvers who improve the quality of life with respect for the environment and human health.

2:15 34.7 Integrated Pest Management—A Simple Solution to Wicked Problem Pests in Elderly and Disabled Public Housing, Dawn H. Gouge, dhgouge@email.arizona.edu, Department of Entomology–Arizona Pest Management Center, University of Arizona–MAC, Maricopa, AZ; Shujuan (Lucy) Li, Shaku Nair

This case study describes efforts to implement an IPM program in HUD subsidized multiunit properties that house low-income elderly and persons with disabilities. Wicked problems may be defined as those in which social complexity means there is no determinable stopping point. Pest infestation levels were evaluated using regular inspections and the use of monitoring traps. New control measures included vacuuming, wall-void treatments with amorphous silica gel, mattress encasements, the use of gel bait insecticide products for German cockroaches, and applications of dual action pyrethroid and neonicotinoid products for bed bugs. Results over 2 years showed significant reduction of German cockroaches and bed bugs. Averaging reductions across all sites there was an 87% reduction in units with German cockroaches and an 88% reduction in units with bed bugs.

2:25 34.8 An Example of Private Sector Contribution in Promoting IPM Practices among Farming Community in Morocco, Rachid El Aini, elaini80@yahoo.fr, IPM Department, Omnium Agricole du Souss, Morocco

The agricultural sector is an important lever for the economic development and sustainable livelihoods of the populations in Morocco. Increased production is being promoted with implications for amplified use of synthetic pesticides. However, production of crops for export forces producers to adopt IPM approaches due to the stringent requirements imposed by importers. Hence, in addition of public institutions efforts, successful IPM projects have been performed by the private sector. The implementation of a Biological Control Agents and pollinators production unit by Omnium Agricole du Souss is an example. Several outstanding achievements have been derived from this project.

35 • Organic Agriculture with Bio-intensive Pest Management as a Means to Adapt/Mitigate Climate Change

Guilford

Around the world, entomologists are striving to control insect pests to maintain the quality and abundance of food, feed, and fiber produced by growers. The intensity of pest damage has increased over the years due to several factors and climate change is one of them. Different approaches may be used to prevent or control insect pests. Chemical pesticides are threats not only to the environment but also to human health. Hence the focus is on organic agriculture using potential biological control agents for pest management. Organic farming practices are known to help in adapting to and also mitigate climate changes by locking in more carbon and reducing emissions of GHGs. The need of the hour is to develop strong repositories of most potential bioagents to form integral components of Bio-intensive pest management modules. However, the search for novel macrobials (parasitoids and predators) and microbials (viruses, fungi, bacteria and nematodes) should continue with emphasis on those which are effective and compatible with organic farming, especially in the changed climatic conditions. Stress tolerant strains of biocontrol agents can play a very important role in pest and disease management. The bio-agents and the technologies for producing the potential bioagents in a large scale should be made available to commercial entrepreneurs. It is high time to conduct research on the bioagents suitable to varied climatic conditions and utilize them as per the situations. NGOs and farmers should join hands in promoting biocontrol as the main component for protecting plant health during organic agriculture.

Organizers: O.K. Remadevi, okremadevi@gmail.com, Centre for Climate Change, Bengaluru, Karnataka, India; Chandish Ballal, ballalchandish@gmail.com, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, Karnataka, India

1:15 35.1 Biointensive IPM in Rice: Success Stories, Chandish Ballal, ballalchandish@gmail.com, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, Karnataka, India; Richa

Varshney, ICAR-National Bureau of Agricultural Insect Resources; OS Navik, ICAR-National Bureau of Agricultural Insect Resources

In the last decade, "Tricho-cards" were utilised in 6800 ha of rice in India to tackle the major pests infesting rice. The "Adat grama panchayat" model in the state of Kerala is one of the most successful examples of practical biological control. In 3000 acres of "kole" wetlands of paddy, farmers adopted a biointensive IPM module leading to an annual savings of INR 1500000 and increase in yield of 1.5 tons/ha. Trichogramma based IPM was adopted in the greater Mekong subregion which resulted in 156 kg/ha additional yield and reduction in pesticide input costs by 1500 Yuan/ha.

1:27 35.2 Biological Control of the Asian Citrus Psyllid, *Diaphorina citri*, in the Lower Rio Grande Valley of Texas Using the Ectoparasitoid, *Tamarixia radiata,* Daniel Flores, Daniel.Flores@aphis.usda.gov, United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection & Quarantine, Science & Technology, Center for Plant Health Science and Technology, Mission Laboratory, Edinburg, TX; Christopher Vitek, The University of Texas–Rio Grande Valley; Matthew Ciomperlik, USDA APHIS PPQ S&T CPHST Mission Laboratory

Tamarixia radiata is a biological control agent of the Asian citrus psyllid (ACP) that is being used as a tool to help suppress ACP from spreading citrus greening in urban environments of citrus growing areas in Texas. Methods have been developed to produce large numbers of these beneficial insects for field release. To date a cumulative total of over 6.8 million *T. radiata* have been produced since 2011. ACP nymph levels in 2010 were reported at 43 nymphs per flush. After releases were initiated, ACP nymph populations were reduced to 2.4 nymphs per flush, a reduction of 94.2% of the vector population.

1:39 35.3 Cassava (*Manihot esculenta* Crantz): A befitting crop for the isolation of insecticidal principles, C.A. Jayaprakas, prakashcaj@gmail.com, Division of Crop Protection, ICAR-Central Tuber Crops Research Institute, Trivandrum, Kerala, India; R.S. Sreerag; G. Ragesh; Jithu U Krishnan; Ajesh

Growing concern of indiscriminate use of synthetic pesticides has globally inspired for massive drive to explore plants and other biocontrol agents in pest management strategies. Cassava, *Manihot esculetna* (Crantz) is an important tuber crop cultivated in tropical and subtropical countries for food feed and industrial products. We have isolated the insecticidal molecules from its leaves and developed two biopesticides against certain cosmopolitan sucking pests of horticultural crops. A Pilot Plant to augment the production of insecticidal principles from cassava was designed and fabricated.

1:51 35.4 Metarhizium formulations for control of Teak and Ailanthus defoliators in forestry, T. O. Sasidharan, tosasi@atree.org, Entomology, ATREE, Bengaluru, Karnataka, India; O.K. Remadevi, EMPRI, Bengaluru; N. Sapna Bai, ATREE, Bengaluru; Priyadarsanan Dharmarajan, ATREE, Bengaluru

Three promising isolates of *Metarhizium anisopliae,* viz., MIS2, MIS7 and MIS13, were identified for development of bio-control formulations for application in forestry. Two liquid formulations containing combinations of the isolates, either alone or mixed with 0.5% *Pongamia pinnata* seed oil, were field tested for management of three major defoliators, viz., *Hyblaea puera* of teak and *Eligma narcissus* and *Atteva fabriciella* of *Ailanthus*. Application of 'MIS2+MIS7+*P.pinnata* oil' formulation reduced the infestation of *Hyblaea puera* up to 63.6% and 56.2%, in teak nurseries and plantations. 'MIS7+MIS13+*P.pinnata* oil' formulation was more effective against *Ailanthus* pests, *E. narcissus* and *Atteva fabriciella* with 60.5 and 66.4% reduction of infestation.

2:03 35.5 Role of entomopathogenic nematodes in integrated pest management, Nagesh Mandadi, nagesh55@yahoo.com, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, Karnataka, India; P. Jagadeesh, A.N. Shylesha, K.S. Murthy, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, Karnataka, India

Entomopathogenic nematodes (EPN) belonging to Heterorhabditidae and Steinernematidae are potential IPM components in several soil-borne pest-crop situations for their ability to quick-kill, reduce pesticide use and proliferate with minimal distress to beneficials. Concern over pesticides leading to groundwater contamination, residues in food and resistance development prompted search for safer alternatives to strengthen IPM. Native EPNs were studied for their field efficacy against whitegrub spp. (Coleoptera:Scarabaeidae) infesting arecanut and sugarcane cropping systems in southwest India. Application of *Heterorhabditis indica* and *Steinernema abbasi* complimented with light traps and sprays to tree-canopy checked the population of grubs and beetles, thus ensuring crop health.

2:15 35.6 Botanicals from trees and weeds as biopesticides against forest insect pests, O.K. Remadevi, okremadevi@gmail.com, Centre for Climate Change, Environmental Management and Policy Research Institute, Bengaluru, Karnataka, India; Deepa Balan, CSIR-NIIST,Thiruvananthapuram

Eco-friendly approaches like usage of biopesticides are considered the best alternatives to chemical pesticides today. The effectiveness of botanicals made from organic extracts of wood of *Pterocarpus marsupium*, seeds and leaves of *Acacia concinna*, seeds of *Erythrina indica*, flowers and seeds of *Butea monosperma*, leaves of *Strychnos nuxvomica*, flowers of *Delonix regia* and leaves of weeds, *Lobelia nicotianaefolia*

and *Chromolaena odorata* were tested for contact toxicity and ovicidal action against the teak defoliator, *Hyblaea puera*. Extracts from the leaves of *L. nicotianaefolia* and seeds of *E. indica* proved as best among the tested plants in their contact/feeding toxicity.

2:27 35.7 The role and importance of extension and education in promoting the message of biointensive IPM for climate resilience, Sujaya Rao, sujaya@umn.edu, Department of Entomology, University of Minnesota, St. Paul, MN

Extension and education programs play a critical role in informing farmers of advances and new technologies related to agricultural production. Extension programs are increasing in importance in today's world with the emergence of new pest issues resulting from climate change. New pest management strategies integrate knowledge related to the biology and ecology of the pest, and of its interactions with other organisms and the environment. It is a challenge for farmers to acquire the required background for successful implementation of such biointensive pest management strategies in the absence of strong educational programs.

36 • Moving IPM Indoors: Reaching Audiences Where They Are

Fells Point

Effectively controlling pests means healthier buildings and residents with fewer asthma attacks, less exposure to pesticides and pathogens, and less financial and workplace stress. To improve pest control in housing IPM training, technical assistance, and resources must be delivered to a diverse audience of stakeholders. Different approaches are necessary with audiences unfamiliar with IPM. The panelists in this session will talk about their work with specific audiences to promote a holistic approach to indoor air quality, foster safe pest control practices, and implement IPM.

Organizer: Susannah K. Reese, sck27@cornell.edu, NE IPM Center, Cornell University, Ithaca, NY

1:15 36.1 Training of community health workers in English and Spanish, Nancy Crider, Nancy.M.Crider@uth.tmc.edu, Cizik School of Nursing, The University of Texas, Health Science Center at Houston, Houston, TX

Dr. Crider will address her work in designing and delivering training to community health workers in English and Spanish. Targeted education in the Texas metropolitan areas and in the border region with high numbers of medically underserved populations allows CHW to increase the impact of educational efforts by reaching these underserved populations who often lack access to pest control and resources.

1:40 36.2 IPM Training in Tribal Housing, Dion Lerman, dll33@psu.edu, Pennsylvania IPM Program, Penn State University, Philadelphia, PA

Mr. Lerman will address IPM training with tribal entities, using his experience to adapt curriculum to meet the individual needs of tribal housing. Although IPM is a familiar agricultural concept, tribal housing often uses conventional pest control practices and they have little access to professional treatment options. The emphasis for training must be on cost-effective and in-house pest control options.

2:05 36.3 Moving IPM Indoors: Reaching Audiences Where They Are, Susannah K. Reese, sck27@cornell.edu, NE IPM Center, Cornell University, Ithaca, NY

This portion of the presentation will address working with residents of affordable housing and overcoming obstacles associated with low sanitation and a lack of cooperation from tenants.

37 • Building Partnerships to Provide Pesticide Safety Education as Part of an IPM Program

Federal Hill

Providing science-based information to our stakeholders is an important part delivering the IPM message. Different programs can be utilized to deliver this information, increase the outreach mission, stakeholder participation in IPM programming and practical application in the field. Understanding how pesticides move around the environment and their potential effects on non-target areas is as vital to having a successful IPM program as it is to preforming an effective and safe pesticide application. The purpose of the session, facilitated by the American Association of Pesticide Safety Educators (AAPSE), is to discuss and demonstrate how IPM and Pesticide Safety Education programs work together along with regional IPM Centers and other groups to share information and resources. Discussions will include new partners, such as the National Pesticide Safety Education Center, and potential new partnerships between existing programs. Participants will be encouraged to share their perspectives on how programs can partner to improve the sustainability of all IPM and Pesticide Safety programs.

Organizer: Kerry Richards, kerryr@udel.edu, American Association of Pesticide Safety Educators, University of Delaware, Newark, DE

1:15 37.1 Incorporating IPM into Pesticide Safety Education Programs, Dean Herzfeld, deanh@umn.edu, Pesticide Safety Education, University of Minnesota, St. Paul, MN

1:35	37.2	Taking it to the field: Working with extension educators and specialists to integrate IPM and pesticide safety to deliver educational program to stakeholders, Kerry Richards, kerryr@udel.edu, American Association of Pesticide Safety Educators, University of Delaware, Newark, DE
1:55	37.3	Partnerships to develop share IPM and Pesticide Safety Education Program resources on a Regional Level, Regional IPM Center Director
2:15	37.4	Partnering to develop and share IPM and Pesticide Safety Education Program on a national level, the concept of a Collaboration Team for IPM/PSEP's, Tom Smith, smitht48@msu.edu, National Pesticide Safety Education Center, Okemos, MI
2:35		Discussion

38 • What Growers and Crop Advisors Need to Know about Managing Brown Marmorated Stink Bug based on the Latest Research

Watertable C

The brown marmorated stink bug, *Halyomorpha halys*, has been detected in 44 states, four Canadian Provinces and is a growing nuisance. Inefficient and unsafe pest control practices are often used instead of IPM strategies developed to combat invasive species. This presentation will expose practitioners to the newest techniques used to manage the spread of brown marmorated stink bug and minimize crop losses.

Organizer: Christian Steponitis, csteponitis@ipminstitute.org, IPM Institute of North America, Madison, WI

1:15	38.1	What growers and crop advisors need to know about managing brown marmorated stink bug based on the latest research, Anne L. Nielsen, nielsen@njaes.rutgers.edu, Rutgers Agricultural Research and Extension, Rutgers School of Environmental and Biological Sciences, Bridgeton, NJ; Dean Polk
2:00	38.2	Biological Control of BMSB in New York State, Peter Jentsch, pjj5@cornell.edu, Cornell University and Hudson Valley Laboratory, Cornell University CALS, Ithaca, NY

39 • IPM Packages for Tropical Crops: How the IPM Innovation Lab Helps Achieve Food Security in the Developing World

Baltimore B

The Feed the Future Innovation Lab for Integrated Pest Management (IPM IL), a USAID funded collaborative research program managed by Virginia Tech has made transformative impacts to improving the livelihoods of smallholder farmers around the world through improving crop production, nutrition, health, income, and food security. The program develops and implements effective IPM technologies and strategies in developing countries as well as transfers technologies and scales them up.

An IPM package is a set of technologies that can include the following components: host plant resistance; soil amendments, biological control; biopesticides; insect mating disruption; grafting; and habitat management through crop rotations, intercropping, antagonistic plants or other organisms, trap crops, roguing, and sanitation, among other practices (including chemical pesticides) .

The focus is on widespread adoption of ecologically based IPM technologies and practices using evidence-based information to reduce losses due to pests, minimizing reliance on synthetic pesticides, and fostering the long-term sustainability of agricultural systems. The IPM Innovation Lab advances IPM science and knowledge, improves communication of IPM information, and catalyzes linkages between public and private entities that drive and disseminate IPM knowledge and technologies.

Organizers: Amer Fayad, afayad@vt.edu, Center for International Research, Education, and Development, Virginia Tech, Blacksburg, VA; Rangaswamy Muniappan, rmuni@vt.edu, Center for International Research, Education, and Development, Virginia Tech, Blacksburg, VA

3:00	39.1	USAID's engagements in IPM under the Feed the Future Initiative, John Bowman, jobowman@usaid.gov, Bureau for Food Security, United States Agency for International Development (USAID), Washington, DC

USAID's Feed the Future Initiative comprehensive approach to crop production and protection is centered on conventional breeding, the use of genetically engineered crops, and the use of integrated pest management (IPM). The integrated pest management innovation lab (IPM IL) program was competitively awarded to Virginia Tech University. This talk will discuss how the IPM IL program fits under the Global Food Security Strategy and how this program ties well with USAID field offices, sustainable intensification, and new initiatives in invasive species modelling and global climate change.

3:20	39.2	IPM for pearl millet in Niger, Malick Ba, B.Malick@cgiar.org, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT),

Niamey, Niger; L. Karimoune, International Crops Research Institute for the Semi-Arid Tropics, Niger; Ibrahim Baoua, University of Maradi, Niger; Rangaswamy Muniappan, Virginia Tech, Blacksburg, VA

Pearl millet is the most important food crop in Niger in West Africa. Major pests are pearl millet head miner (MHM) *Heliocheilus albipunctella* and pearl millet stem borer (MSB) *Coniesta ignefusalis*. Augmentative releases of the larval parasitoid *Habrobracon hebetor* is successfully used in Niger against MHM while no effective biocontrol agent has been developed for MSB. A more effective/early control of MHM may result from egg and larval parasitoids. Recently we identified an egg parasitoid *Trichogrammatoidea armigera* that attacks eggs of MHM and MSB. This give us prospect for IPM of major insect pests of pearl millet in the Sahel.

3:40 39.3 IPM package for rice in Cambodia, Buyung Hadi, b.hadi@irri.org, Crop and Environmental Sciences Division, International Rice Research Institute (IRRI), Los Banos, The Philippines

EPIC, an IPM Innovation Lab IRRI-led USAID-funded project, employs participatory methods to develop an IPM package to address these problems. Weeds, rodents, rice blast and defoliator insect pests were identified as the priority rice yield robbers in different parts of the country. Ecologically-based pest management tactics, such as trap barrier system for rodent management and entomopathogenic fungi for insect pest management, were tested in collaboration with Cambodian farming communities. Most of the ecologically-based pest management tactics tested under EPIC significantly reduced pest injuries, increased rice yield and improved farming profitability compared to the current farmers' practice.

4:00 39.4 Developing an IPM approach to the new invasive pest, the fall armyworm in Africa, Tadele Tefera, ttefera@icipe.org, International Center of Insect Physiology and Ecology (icipe), Addis Ababa, Ethiopia; Birhanu Sisay, Josephine Simiyu, International Centre of Insect Physiology and Ecology, Addis Ababa, Ethiopia; Rangaswamy Muniappan, Amer Fayad, IPM Innovation Lab, Virginia Tech, Blacksburg, VA

Nine chemical and eleven botanical pesticides were tested against the fall armyworm (FAW) in laboratory and greenhouse conditions. Radiant®, Tracer®, Karate®, and Ampligo® caused over 90% larval mortality, 72 hr after application. *Azadirachta indica*, *Schinnus molle* and *Phytolacca dodecandra* resulted in the highest percentage larval. Natural enemies were collected from Ethiopia, Kenya and Tanzania. *Cotesia* sp was the dominant larval parasitoid with 33.8% to 45.3%, parasitism followed by *Archytas marmoratus*, *Charops ater*, and *Coccygidium luteum*. Five commercial pheromone lures were evaluated for trapping FAW male moths. Pheromone traps and natural enemies will be used in an IPM strategy for FAW.

41 • Soybean Cyst Nematode Resistance Management

Homeland

Soybean cyst nematode (SCN) is a key yield-limiting biological factor in soybean production in the U.S.A. The vast majority of available soybean varieties are derived from PI88788. This resulted in development of aggressive SCN populations, loss of PI88788 effectiveness and pending crisis. Without appropriate integrated intervention, soybean growers in many areas are likely to be in a situation where they experience SCN yield loss similar to what existed before the availability of resistant varieties: levels not seen since the 1980's. As the result of a grower survey indicating a lack of awareness of SCN and associated management options, a nation-wide 2nd SCN Coalition has been developed to facilitate adoption of integrated management practices. The Soybean Cyst Nematode Management Session will present the results of a 2015 survey describing the current state of grower knowledge about SCN and management options, describe the development of Iowa SCN populations with increased ability to reproduce on resistant soybean cultivars derived from PI8878 and the resultant consequences on soybean yields, provide an assessment of the SCN Management Tool Box and future needs, and explain the 2nd SCN Coalition: A national communications strategy for resistance management.

Organizer: George W. Bird, birdg@msu.edu, Department of Entomology, Michigan State University, East Lansing, MI

3:00 41.1 2015 Soybean Cyst Nematode Grower Survey, Steve Gomme, steve.gomme@syngenta.com, Soybean Seedcare, Syngenta, Greensboro, NC

To better understand soybean grower perceptions about SCN, a comprehensive survey of 1,096 soybean growers from North Central 17 states was designed by a group of university scientists, funded by an industry partner (Syngenta) and implemented in the fall of 2015. The results indicated that soybean growers lacked knowledge about SCN in regards to development of highly aggressive populations and how to reduce risk to these populations. The presentation consists of a detailed description of the survey development process, the survey instrument and the results of the survey in regards to justification of the need for a comprehensive National Coalition for SCN Resistance Management.

3:20 41.2 The Iowa Story: Consequences of Aggressive SCN Population Development, Gregory Tylka, gltylka@iastate.edu, Department of Plant Pathology and Microbiology, Iowa State University, Ames, IA

The soybean cyst nematode (SCN), *Heterodera glycines*, was successfully managed for decades by growing SCN-resistant soybean varieties in rotation with nonhost crops, such as corn. Unfortunately, almost all of the resistant soybean varieties

were developed with the same resistance genes, from a breeding line named PI88788. This presentation will review data from 25 years of field experiments in Iowa documenting a gradual increase in reproduction of SCN populations in farmers' fields on the PI88788 source of resistance accompanied by increased numbers of SCN eggs produced on resistant soybean varieties with PI88788 resistance and decreased yields of those same resistant varieties.

3:40 41.3 The SCN Coalition Resistance Management IPM Tool Box, George Bird, birdg@msu.edu, Department of Entomology, Michigan State University, East Lansing, MI

The Coalition's SCN resistance management tool box includes all components of the process of IPM. Its moto, Know Your Numbers, mandates scouting through both biological and environmental monitoring. The IPM strategies of exclusion (avoidance) and containment are implemented through crop rotation, clean equipment and clean seed. The strategy of control (population reduction) involves the genetic, biological and chemical tactics of resistant varieties, biological seed treatment and chemical seed treatment, respectively. The key for the success of the Coalition will be the education, facilitation and persuasion required to properly prevent SCN resistance to available genetics, thus preventing the pending crisis.

4:00 41.4 Soybean Cyst Nematode Resistance Management Coalition, Sam Markell, samuel.markell@nedsu.edu, Department of Plant Pathology, Fargo, ND

The mission of the Second Soybean Cyst Nematode Coalition is to develop an SCN Resistance Management and Awareness Campaign to educate growers and industry on the reality of SCN resistance development, to slow the development of highly aggressive SCN populations and to minimize increasing levels of yield loss. The Coalition has multiple partners and is a potential model for IPM program development. This was achieved through implementation of the following seven-step process: 1) SCN Grower Baseline Survey, 2) SCN Awareness and Education Meeting—Kick-starting the Second SCN Coalition, 3) National SCN Conference, 4) SCN Coalition Building and Development Meeting, 5) Develop an SCN Resistance Management and Awareness communication strategy, 6) Securing Buy-in from Industry Partners and Early Implementation and 7) Coalition launch at the 2018 Commodity Classic in Anaheim, California.

42 • IPM in Housing: A Round Table to Discussion on Diversifying the Messenger

Fells Point

The IPM message has been primarily delivered to the pest control industry by Extension specialists with urban pest management responsibilities. Adoption in structural pest control is slow. We realize that the IPM messengers need to be diversified in order to reach a very diverse audience: the general public. Recently, some innovative county agents realized the potential to expand the base of those who could benefit from IPM: those who attend housing counseling courses that include a home maintenance section. We proposed (CPPM-EIP) to include an IPM module in the home maintenance programming that highlights IPM as a hidden benefit of property maintenance. Our county agents have backgrounds in Family, Youth, and Community Sciences, Housing, and Horticulture. We call these county faculty: non-traditional change agents (NICA). Their programming reaches homeowners directly. Our overarching goal of having people live in healthy and structurally sound homes. Another goal is to create IPM demand by providing information to homeowners directly. In this 90-minute session, we seek to share our project objectives including a list of existing home-related programs and resources, invite partnerships with other institutions, and welcome ideas for future funding with program evaluation guidance.

Organizers: Faith Oi, foi@ufl.edu, Entomology, University of Florida, Gainesville, FL; Shanika Preston, spreston4@ufl.edu, Seminole County Extension, University of Florida, Sanford, FL; Janet A. Hurley, jahurley@ag.tamu.edu, Department of Entomology, Texas A&M AgriLife Extension, Dallas, TX

3:00 42.1 Adventures in Housing IPM, Dini Miller, dinim@vt.edu, Entomology, Virginia Tech, Blacksburg, VA

3:15 42.2 Diversifying the IPM Messenger: Combining Finance and Mortgage Training with IPM, Shanika Preston, spreston4@ufl.edu, Seminole County Extension, University of Florida, Sanford, FL

3:30 42.3 How Pests in Homes Come to School, Janet A. Hurley, jahurley@ag.tamu.edu, Department of Entomology, Texas A&M AgriLife Extension, Dallas, TX

3:45 42.4 Building Capacity in Extension and the Pest Control Industry, Faith Oi, foi@ufl.edu, Entomology, University of Florida, Gainesville, FL

4:00 42.5 Round Table Discussion

43 • Diagnostics, Biosecurity and IPM—Imagine the Future

Federal Hill

The tremendous growth in global trade and travel and the consequent movement of pests and pathogens into environments made uncertain by climate change, increases the risk of negative impacts to productivity, profitability and sustainability of plant systems. Rapidly advancing detection and communications technologies are making possible point-of-care strategies for more effective response to the ever increasing introductions of exotic, and the emergence of new, pests and pathogens.

The basis of effective response is the accurate identification of the pest or pathogen and the timely communication of accurate information to inform response. There are multiple examples of failed response efforts due to mistaken identities, incomplete and delayed communications and inaccurate predictive models. Next Generation-based, field-deployable detection technologies coupled to advanced communications technologies are bringing the power of the lab to the field. The future of IPM is bright as it embraces these new technologies and implements new strategies to protect plant systems from the pests and pathogens that threaten plant health.

Organizers: Martin A. Draper, maddr@ksu.edu, National Plant Diagnostic Network, Kansas State University, Manhattan, KS; James P. Stack, jstack@ksu.edu, Great Plains Diagnostic Network, Kansas State University, Manhattan, KS

3:00	43.1	Increasing disease pressures on plant systems: Challenge or Opportunity for IPM?, Carrie L. Harmon, clharmon@ufl.edu, Southern Plant Diagnostic Network, University of Florida, Gainesville, FL
3:15	43.2	Increasing insect pressures on plant systems: Challenge or Opportunity for IPM?, Laura J. Jesse Iles, ljesse@iastate.edu, North Central Plant Diagnostic Network, Iowa State University, Ames, IA
3:30	43.3	Advanced detection and communications technologies to inform IPM, James P. Stack, jstack@ksu.edu, Great Plains Diagnostic Network, Kansas State University, Manhattan, KS
3:50	43.4	A 21st Century Vision for IPM—Imagine the future, Martin A. Draper, maddr@ksu.edu, National Plant Diagnostic Network, Kansas State University, Manhattan, KS
4:10	43.5	Discussion

44 • Effective Strategies for Minimizing Losses from Bagrada Bug

Watertable C

Effective IPM strategies to minimize the losses of bagrada bug, such as microbial control, offer an alternative to less efficient control practices. As a growing problem in the west coast, preventative actions must be used in order to stop future infestations. In this session practitioners will learn how to identify this pest, and when and how to effectively act against this invasive species.

Organizer: Christian Steponitis, csteponitis@ipminstitute.org, IPM Institute of North America, Madison, WI

3:00	44.1	Effective strategies for minimizing losses from bagrada bug, Surendra K. Dara, skdara@ucdavis.edu, Division of Agriculture and Natural Resources, University of California, San Luis Obispo, CA

45 • Vector-Borne Diseases

Watertable Ballroom

Vector-borne diseases are in the spotlight. What is the next one to come? This session will discuss integrated management strategies for dealing with these diseases.

Organizer: Stanton Cope, secope29@gmail.com, Atlantic Paste & Glue (Catchmaster), Lake Bluff, IL

8:30	45.1	Reviving the Promise of Integrated Vector Management, Michael Macdonald, macdonaldm@macito.net, Baltimore, MD

IVM is defined as "a rational decision-making process for the optimal use of resources for vector control." Developed by WHO in 2004, IVM includes five elements: advocacy, social mobilization and legislation; cross-sector collaboration; integration; surveillance; and capacity-building. Eighteen years on, results are mixed; some success against Anopheles malaria vectors, but challenged by insecticide resistance, outdoor transmission and humanitarian emergencies. Aedes control has been a failure for many countries. In 2018 WHO, through the "Global Vector Control Response" is attempting to revive principles of IVM and lessons from IPM to address fragile gains against malaria and the continued threats of Aedes-borne diseases.

8:50	45.2	What is The Next Zika?, Stanton Cope, secope@gmail.com, Atlantic Paste and Glue (Catchmaster), Lake Bluff, IL

This presentation will discuss factors which contribute to mosquito-borne disease outbreaks and we will speculate on what the 'next Zika' might be.

9:10	45.3	Integrated Mosquito Management, Joseph Conlon, conlonamcata@gmail.com, American Mosquito Control Association, Fleming Island, FL

Integrated Mosquito Management (IMM) is a comprehensive mosquito prevention/control strategy that utilizes availlable mosquito control methods singly or in combination to exploit the known vulnerabilities of mosquitoes in order to reduce their numbers to tolerable levels while maintaining a quality environment. This presentation will discuss the manner in which IMM is practiced in the United States today.

9:30	45.4	Chagas Disease: On The Doorstep, Stanton Cope, secope@gmail.com, Atlantic Paste and Glue (Catchmaster), Lake Bluff, IL

The causative agent of Chagas disease is widespread and we have competent vectors, yet there have only been a handful of confirmed human cases. We will examine what the threat is in the US and speculate on the future.

46 • Pesticide Use Determinants and Human Health

Federal Hill

Pesticides enable effective crop protection and the production of larger quantities of crops. However, there are numerous important social and environmental externalities of pesticide use. Of particular concern is the potential for pesticide exposure to affect human health. This session includes four studies on pesticide use and human health issues. Ashley Larsen (University of California) examines the determinants of pesticide use hot spots in the agriculturally dominated San Joaquin Valley, California and their persistence year-to-year. The temporal consistency in the results suggests that a substantial fraction of pesticide use is routine rather than reactive, while the seasonal peaks in pesticide use indicate that specific birth months are likely to experience substantially more pesticide use over gestation than others. Wei Zhang (International Food Policy Research Institute) investigates semi-subsistence farm households' pesticide application decision-making for managing production, income, food security, and health risks in Cambodia and Vietnam. Ricardo Maertens (Pompeu Fabra University) investigates the effect of policy-induced increase in corn production on the incidence of fetal conditions and incidence of perinatal death in the US. Paul Jepson (Oregon State University) discusses a suite of programs that limit the use of highly hazardous and high risk pesticides in the US, West Africa, and in high value, sub-tropical, export horticulture, and reports outcomes from the Western Pesticide Risk Management Network that is establishing extension IPM procedures to communicate and limit pesticide hazards.

Organizer: Wei Zhang, w.zhang@cgiar.org, Environment and Production Technology, International Food Policy Research Institute, Washington, DC

8:30 46.1 Elucidating the striking seasonal variability in agricultural pesticide use and the implications for surrounding communities, Ashley E. Larsen, larsen@bren.ucsb.edu, Bren School of Environmental Science & Management, University of California, Santa Barbara, Santa Barbara, CA; Emily A. Martin, University of Würzburg

The consequences of pesticides for human health are partially determined by overlap of pesticide exposure with sensitive developmental stages. Yet, data limitations have inhibited understanding when and where high levels of pesticides occur. We leverage refined pesticide data from California to investigate spatial and temporal dynamics of pesticide hot spots and their persistence year-to-year. We show use is crop-specific with distinct peaks and troughs in pesticide use that are consistent year-to-year. These results suggest that a substantial fraction of pesticide use is routine and that specific birth months are likely to experience substantially more pesticide use over gestation than others.

8:50 46.2 Disentangling determinants of insecticide use to manage production, food security, and health risks: Evidence from Cambodia and Vietnam, Wei Zhang, w.zhang@cgiar.org, Environment and Production Technology, International Food Policy Research Institute, Washington, DC; Yanyan Liu, IFPRI; Andrew Bell, New York University

Using field data collected from household survey and risk assessment experiments in 2014 in Cambodia and Vietnam, we disentangle the determinants of insecticide use and identify whether health consideration has had any influence on insecticide use. Results indicate both push and deterring factors at household, plot, and crop levels in dictating insecticide use decisions. Crops (except for rice) whose outputs are used to a greater degree for consumption are less likely to be sprayed or sprayed fewer times. Health-conscious households consistently refrain from spraying, but this tendency diminishes as outputs shifting toward commercial use, suggesting a possible moral hazard phenomenon.

9:10 46.3 Biofueling poor fetal health?, Ricardo Maertens, maertensodria@fas.harvard.edu, Department of Economics, Harvard University, Cambridge, MA

The introduction of the 2005 Renewable Fuel Standard in the United States increased the demand for corn ethanol and led to heterogeneous increases in the production of corn, a pesticide-intensive crop. By combining the introduction of the Renewable Fuel Standard, county-level variation in potential for corn expansion, seasonal variation in corn pesticide applications during the growing year, and variation in fetal month of conception, I find that the policy-induced increase in corn production increased the incidence of abdominal wall defects, being born small-for-gestational age, and perinatal death in the U.S. Corn Belt.

9:30 46.4 Limiting the impacts of highly hazardous pesticide use on human health, Paul C. Jepson, paul.jepson@oregonstate.edu, Integrated Plant Protection Center, Dept. Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR; O. Bach, M.L. Halbleib, M.K. Murray, M. Sarr, C.E. Donald, K.A. Anderson

We describe a suite of programs that limit use or management of highly hazardous and high-risk pesticides in the USA, West Africa, and in high-value, sub-tropical, export horticulture. In the USA, the Western Pesticide Risk Management Network is establishing extension IPM procedures that communicate and limit pesticide hazards. In West Africa, new human health risk assessment procedures for applicator, dermal and inhalation exposure are being used within participatory education

programs. In sub-tropical export horticulture, we outline how new certification standards provide the basis for greater human health protection when pesticide management standards are merged within an IPM requirement.

47 • Partnerships to Strengthen the Role of Pest Exclusion in IPM

Homeland

Proponents of IPM in urban/structural pest management have long recognized the importance of exclusion as a pest prevention technique. As an industry, pest management professionals are poised to provide exclusion services based on knowledge of conditions that are conductive to, and supportive of pest entry. To date, however, adoption of exclusion remains low. To combat this, the Scientific Coalition on Pest Exclusion (SCOPE) initiated the SCOPE 2020 campaign to raise awareness and prompt adoption of exclusion. An additional route to adoption of exclusion is by incorporating pest prevention principles into efforts of other organizations and trades. In this session, we will explore adoption of pest exclusion as it relates to weatherization, fire prevention, new construction, building certification, and food safety. The session will also include a history of exclusion, current research on pest movement in buildings, benefits of exclusion for asthma and allergy reduction, and a discussion on future research needs for adoption. The goal of this session is to empower attendees with ways to engage non-traditional partners in promoting exclusion to reduce pest populations and associated problems.

Organizers: Jody L. Gangloff-Kaufmann, jlg23@cornell.edu, NY State IPM Program, Cornell University, Babylon, NY; Matthew J. Frye, mjf267@cornell.edu, NY State IPM Program, Cornell University, Elmsford, NY

8:30 47.1 Open Doors: An Overview of Pest Exclusion's Past and Present, Robert M. Corrigan, cityrats@icloud.com, RMC Pest Management Consulting, Ossining, NY

An introduction and history of structural pest exclusion and why exclusion is finally having its day. There are four highly utilized structural routes of entry by pests into our buildings, but of which none are highly difficult to alter to achieve pest exclusion. Yet, for nearly a century, and despite the advice of early urban pest experts, holes in walls and gaps beneath everyday doors remained unattended to. With the advent of chemical pesticides, the expectation perhaps was residual exterior insecticidal sprays and rodenticidal baits could replace the need for common-sense structural repairs. But in a full circle pest exclusion is gaining attention and thus momentum for being re-instated into its proper scientific and intellectual spot: the truest corner-stone of urban IPM programs.

8:40 47.2 Pests All Over: Distribution of German Cockroaches and Bed Bugs in Apartments, Changlu Wang, changlu.wang@rutgers.edu, Department of Entomology, Rutgers University, New Brunswick, NJ

Cockroaches and bed bugs are prevalent pests of multifamily housing communities. Both of these pests have the ability to move between apartments contributing to high infestation rates and chronic pest activity. Understanding distribution of cockroaches and bed bugs is essential in effectively managing these pests on a building-wide basis and can provide important information for exclusion efforts.

8:50 47.3 Reducing Asthma and Allergies with Pest Exclusion, Marc L. Lame, mlame@indiana.edu, School of Public and Environmental Affairs, Indiana University, Bloomington, IN

This talk will concentrate on our mantra from School IPM "do what you are doing now, just think pests." My logic for sealing buildings with regard to pests and pesticides is 1) you have to manage/design airflow to keep the building and occupants healthy AND conserve energy 2) a monitoring system is the backbone of such a system and 3) continuous maintenance makes it work. All of these basic but fundamental activities require political will as a resource. The same such fundamentals and resource align perfectly with a good IPM system.

9:00 47.4 Exclusion: The Future of Pest Management, Jody L. Gangloff-Kaufmann, jlg23@cornell.edu, NY State IPM Program, Cornell University, Babylon, NY

Keeping pests out of buildings is common sense. Pest exclusion is one of the pillars of an integrated pest management program, but it is often overlooked or neglected due to costs or lack of skills. This presentation will cover barriers to the adoption of pest exclusion as an IPM tool and strategies for encouraging pest managers to do more of it.

9:10 47.5 IC SCOPE: What We Have Learned So Far about Pest Exclusion in Industrial and Commercial Habitats, Stephen Kells, kells002@umn.edu, Department of Entomology, University of Minnesota, St. Paul, MN

Insect and rodent pests are very able to use structural faults in residential and commercial buildings. When pests invade structures, their activity causes substantial health problems and costs for people and companies. The best way to deal with infestations is to prevent their entry and stop them from spreading within buildings. However, for several reasons this common-sense approach has struggled to become a common-used approach. The Scientific Coalition On Pest Exclusion (SCOPE) is a group of scientists, pest managers and facility managers who have the goal to bring scientific study to exclusion practices. The ultimate goal is to provide the end-user

practical guidance for, and resulting confidence in, identifying building faults and deploying exclusion methods. This presentation will discuss the challenges found in industrial and commercial habitats (IC) that interfere with increasing practical pest exclusion as a critical IPM component in these buildings.

9:20 47.6 Lessons learned from building pest prevention into 3,500 low-income housing units, Chris Geiger, chris.geiger@sfgov.org, Department of the Environment, City of San Francisco, San Francisco, CA

Dr. Geiger will summarize lessons learned during the Rental Assistance Demonstration (RAD) project in San Francisco, a massive public housing rehabilitation project that incorporated pest preventive design elements.

9:30 47.7 Regulating holes: Enhancing the exclusion and containment envelope, Richard Pollack, richard_pollack@harvard.edu, Department of Immunology and Infectious Diseases, T.H. Chan School of Public Health, Cambridge, MA

Penetrations for mechanical, electrical, plumbing, communications systems provide portals to networks of pest friendly superhighways throughout our dwellings. Designers and contactors tend to be woefully ignorant of the significance of penetrations, and the operational managers who assume control of the structures inherit perpetual costly and difficult pest management burdens that could largely be averted. Proactive exclusion practices can be impressively effective, sustainable, environmentally-appropriate, and can dramatically reduce risks and costs associated with pests. New fire code regulations, building standards and best management practices that prescribe plugging holes for firestopping purposes, for example, serve as useful 'hooks' to encourage and compel architects and contractors to consider enhancing pest security as well. This presentation will highlight specific exclusion opportunities and solutions. Although such elements are ideally adopted during initial facility design and construction, they can be applied—albeit with more difficulty and cost—later to mitigate ongoing pest problems.

poster abstracts

*Note: * by author name indicates presenting author*

P1 Be part of the buzz! A live conversation about biocontrol at the 9th International IPM Symposium

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Join the conversation! Why is biocontrol part of your IPM strategy? What are your biggest biocontrol challenges? Do you see new opportunities for biocontrol implementation? Faculty, extension professionals, producers, and those involved in community pest management around New York State have their opinions, but what is most important for your geographic location and pest management setting? Vote on the barriers and opportunities that are most relevant where you practice IPM, suggest additional answers, share your opinions, and see what your colleagues are saying, either at the physical poster, or online. Biological control products and organisms are increasingly available and in-demand in all pest management settings—from agricultural fields, to homes and schools, to natural landscapes. Because of this, there are both exciting opportunities for, and important challenges to, using biocontrol as part of an IPM strategy. Through this poster, you can share ideas about stakeholder needs for managing microbe, arthropod, weed, and vertebrate pests, the barriers that prevent the use of biocontrol against these pests, and the ways in which biocontrols might be especially well-suited to managing them. Sharing this information will ultimately contribute to enhanced biocontrol use across diverse pest management settings.

P2 Hedgerow benefits align with food production and sustainability goals

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Restoring hedgerows, or other field edge plantings, to provide habitat for bees and other beneficial insects on farms is needed to sustain global food production in intensive agricultural systems. To date, the creation of hedgerows and other restored habitat areas on California farms remains low, in part because of a lack of information and outreach that addresses the benefits of field edge habitat, and growers' concerns about its effect on crop production and wildlife intrusion. Field studies in the Sacramento Valley highlighted that hedgerows can enhance pest control and pollination in crops, resulting in a return on investment within 7 to 16 years, without negatively impacting food safety. To encourage hedgerow and other restoration practices that enhance farm sustainability, increased outreach, technical guidance, and continued policy support for conservation programs in agriculture are imperative. A hedgerow bordering an almond orchard in Yolo County has been planted with native flowering shrubs and a forb understory of annual and perennial wildflowers. Hedgerows support bees and other pollinators as well as the natural enemies of pest insects and mites.

P3 Soil solarization for integrated pest management in the Pacific Northwest (USA)

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Solarization employs solar radiation to heat the soil under a transparent plastic film to achieve temperatures detrimental to certain soilborne pathogens and weed seeds. Most soil solarization studies have been conducted in warm climates, but recent advances in plastic film technology have made it feasible to successfully solarize soil in regions with cooler climates such as the Pacific Northwest. In 2015-2017, we conducted pre-plant soil solarization trials during the summer months for durations of 2 to 9 weeks in Oregon nurseries. We found significant reductions in soil populations of plant pathogens (*Phytophthora* spp., *Pythium* spp., and *Fusarium oxysporum*), reduced emergence of weed species, and increased growth of a subsequent crop in solarized treatments relative to a non-solarized control. We developed an online model http://uspest.org/soil/solarize for growers to estimate the time necessary to solarize soil based on their farm location, start date, and target pest. The model forecasts soil temperatures from solar radiation and air temperature data at local weather stations, and predicts the amount of time necessary to kill target weed seeds and plant pathogens based on results from controlled environment studies. Soil solarization is a cost-effective, non-chemical approach to IPM that could potentially be applied to other Pacific Northwest cropping systems such as organic vegetables and berry crops.

P4 Weather and climate driven models for IPM and invasive species management

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Predicting the timing of pest management activities is a crucial component of IPM and invasive species management. We provide an overview of the many uses of the online decision support tools at USPEST.ORG. There are numerous models for insect, weed, and crop phenology (105 total), and an additional 25 that are used for forecasting plant disease risk. Weather, climate, and forecast data are available for over 26,000 weather station locations and for gridded modeling and mapping needs. The models incorporate Fox Weather, LLC 7-day and 90 day forecasts, and NOAA/NWS 7-day and 7-month forecasts. We highlight new IPM models for this 20-years-existing website including the potato/tomato psyllid [*Bactericera cockerelli* (Šulc)], the threecornered alfalfa hopper [*Spissistilus festinus* (Say)], three new weed species, and a new model for pesticide vapor or thermal drift. New models that are classified as invasive species include the Asian longhorned beetle [*Anoplophora glabripennis* Motschulsky], the common cutworm [*Spodoptera litura* F.], and the Japanese flower thrips [*Thrips setosus* Moulton]. We also demonstrate new features at the website including interactive Highcharts and a new infrastructure for online creation of custom degree-day maps. Model uptake and usage has been steadily increasing; degree-day models alone exceeded 60,000 runs during each of the past four years.

P5 Grower valuation of the Network for Environment and Weather Applications

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The Network for Environment and Weather Applications (NEWA) is an online decision aid platform used by fruit and vegetable producers throughout the Northeast, Midwest and Mid-Atlantic United States. Real time data are sent to NEWA from 588 grower-owned Rainwise weather stations, partnering weather networks, and National Weather Service locations. Within NEWA, 43 models are programmed using location-specific weather data to provide agricultural insect and disease risk assessments, crop management models, weather tools, and weather risk. In 2017, a Qualtrics survey was completed to measure the informative and economic value of NEWA to growers. Results show that, by wide margins, NEWA reduces the number of pesticide sprays, improves spray application timing, informs growers of pest risk in a timely fashion, and enhances IPM management decisions. Results from the 2017 survey will be used to devise a strategy for building a new website platform to improve NEWA. Results will also support ongoing efforts to document IPM impact throughout the 13-state region that NEWA encompasses, and will also serve as an important grant leveraging resource to research and extension colleagues who collaborate with NEWA. Results will also inform future efforts to expand the number and types of growers who benefit from NEWA.

P6 The effects of mulching leaves in place on tick populations in lawns and parks

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In an effort to reduce waste management costs, several municipalities in Westchester County are encouraging homeowners to mulch fall leaves in place. With this push to "leave them on the lawn," questions have been raised about the effect this practice may have on tick habitat. Assessing tick populations on lawns will help determine if mulch mowing can affect tick populations and thus vector-borne disease incidence. Tick populations were evaluated on fourteen plots at twelve sites, which represent eight home lawns and four public parks in Westchester County, NY. Five sites have been mulch-mowed for 1-3 years, four have been mulch-mowed for 4-7 years, and five sites have had leaves removed in the fall. Each site was dragged for ticks one time per week for six weeks in the spring, seven weeks in the autumn, and (in 2015 only) once each in July and August. Collected ticks were identified to species and life stage and tested for tick-borne diseases. The number of collected ticks was very low, with only 19 ticks collected in 2015, 12 in 2016, and 31 in 2017. While the low numbers do not allow for statistical analysis between treatments, the fact that we collected even this low number of ticks in the middle of high end lawns has proven to be an important education point. We are currently evaluating next steps to determine BMPs for leaf management on turfgrass areas, especially golf courses that need to remove leaves from playing surfaces.

P7 Occurrence of egg parasitism in the exotic pest brown marmorated stink bug and the native beneficial spined soldier in three Maryland habitats

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Brown marmorated stink bug (*Halyomorpha halys*; BMSB) is a widespread invasive pest feeding on a wide variety of fruits, vegetables, and other plants in many habitats. To understand and encourage factors which may control it, we must first investigate which natural controls, including parasitoids of the egg stage, attack BMSB in the different habitats it infests. This study during the growing seasons of 2015, 2016, and 2017 placed both BMSB and *Podisus maculiventris* (the spined soldier bug, a native beneficial non-target species) egg masses into three different BMSB habitats in Maryland (soybean, apple orchard, and wooded edges) to determine the prevalence of egg parasitoid attack, and whether emergence of the parasitoids was successful, no bugs or parasitoids emerged (indicating unsuccessful parasitism), or bugs emerged for each egg mass type. During this study, we determine the attack rates of both native and adventive parasitoid populations including *Trissolcus japonicus*, which was previously being studied for release as a classical biological control agent. We also deployed egg masses at various heights (5', 10', 15', and 20') in the canopy by affixing egg masses to bamboo poles next to various tree species. Frozen BMSB, and fresh *P. macuiventris* egg masses yielded the most successful parasitism by native parasitoids, and lab-reared 24-hour-old BMSB egg masses the least by natives, indicating that live BMSB eggs are not good hosts for native parasitoids as they are not co-evolved. However, the exotic parasitoid, *T. japonicus*, parasitized and emerged successfully from lab reared 24-hour-old egg masses, indicating that, unlike American natural enemies, it is well-adapted to its Asian host. Results will help researchers determine what actions may best be taken to introduce additional exotic natural enemies and/or conserve natural enemies already present in Maryland, to help manage this invasive pest.

P8 Insights into winter survival strategies of North American hover flies (Syrphidae) and the implications for pollination and conservation biological control

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Understanding the winter biology of beneficial insects such as hover flies (family Syrphidae) is an understudied, yet vastly important area of research. The adult stages of most hover fly species are important pollinators of a variety of crops, while the larvae are effective biological control agents of aphids. It is known that in Europe, some species exhibit a unique winter survival behavior in which certain individuals migrate hundreds of miles south in response to encroaching winter conditions, while others diapause and remain local. No studies to date, however, have investigated these behaviors in North American species. The purpose of this project, therefore, is to investigate the migratory status of common North American hoverflies using a combination of wing morphometrics and stable isotope analyses. Specimens belonging to four species were collected every two weeks from July-October in Urbana, IL, and their wing length, wing area, intertegular span, and dry weight were measured. We are finding that certain individuals during certain weeks have longer, larger wings, and a larger intertegular span in proportion to body size, indicating that they are allocating resources towards flight. This means that individuals may be undergoing long-distance movement. Better understanding the winter survival strategies of hoverflies will improve pollination and efficacy of aphid control, providing valuable cost and time saving alternatives for growers.

P9 The impact of organic crop rotations and ecological weed management strategies on soil quality

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The use of cover crops within organically managed systems is a common practice to suppress weed populations and improve various soil biological, chemical, and physical properties. Our objectives were to evaluate the impacts of several cover crops on soil quality in an organic system in a 5 year study located in Ithaca, Nebraska by measuring several soil quality parameters. The cover crop treatments used to suppress weed species and improve soil health in this study were sunn hemp (*Crotalaria juncea*), nitro radish (*Raphanus sativus*), turnip

(*Brassica rapa*), red clover (*Trifolium pratense*), and a mixture of mustards species (Brassica spp.), all cover crop options, and no cover crops. The soil quality indicators measured were macroaggregate stability, bulk density, electrical conductivity, soil test potassium, soil test phosphorous, total organic carbon and soil microbial biomass. How the 3 year organic corn-soybean-wheat crop rotation, and cover crops within that organic rotation, influenced soil quality, was assessed using the Soil Management Assessment Framework (SMAF). How these same treatments influenced soil microbial communities was assessed by integrating below ground and above ground measurements using a random forest classification and regression model. Understanding how cover crops and organically managed systems impact soil quality may serve to encourage producers in adopting organic practices.

P10 Evaluation of anaerobic soil disinfestation for ecofriendly weed management

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Weeds cause significant economic losses in farming systems due to competition for nutrients, light and moisture, inhibition of growth and reproduction through allelopathy, and harboring diseases and pests of crops. Current weed management practices are labor intensive or rely heavily on synthetic herbicide application. Anaerobic Soil Disinfestation (ASD) is a promising technique for weed, disease and pest management, with no known health or environmental consequences. The purpose of this study was to explore the efficacy of ASD with locally available carbon sources on inactivation of propagules of major weed species. Germination and viability of seed/tubers of seven weed species: common lambs quarters (*Chenopodium album*), foxtail (*Setaria* spp.), black nightshade (*Solanum nigrum*), yellow nutsedge (*Cyperus esculentus*), American pokeweed (*Phytolacca decandra*), dandelion (*Taraxacum officinale*), and redroot pigweed (*Amaranthus retroflexus*) were tested with four carbon sources: molasses, wheat bran, mustard green leaves, and raw chicken manure in a factorial completely randomized design in a growth chamber. Wheat bran was the most effective carbon source for inactivation of all weed propagules, followed by molasses. Only higher amounts (> 10 g dry matter per Kg soil) of mustard green leaves inactivated all of the weed propagules. Chicken manure only inactivated dandelion and nutsedge propagules. Results of the study indicate potential of ASD with wheat bran and molasses as carbon sources in weed management. This may be an effective weed management practice for organic farmers who have limited options, and in developing regions where herbicides are unavailable or prohibitively expensive.

P11 Reaching out to the Big Sky

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Montana is one of the least populated states in the United States with an average of 6.5 people per square mile. There are 27,500 farms and ranches in the state. Outreach to populations across the state is challenging due to distance, a low number of specialists, access to technology, and receptivity of different audiences to technology. The MSU Extension IPM Program has created a communication network that allows stakeholders access to current science-based information as well as allowing feedback from stakeholders to set priorities for educational and research needs. The cornerstone of the IPM program is the Schutter Diagnostic Lab housed at Montana State University in Bozeman, Montana. Each sample (>2000/y) is an opportunity to educate the client about pest identification and IPM-based management. Samples are used as the basis of time-sensitive alerts and for research. Urban and agricultural alerts are distributed via email, text, and fax. Information is also available through websites, texting specialists, Facebook, Twitter, Instagram, and a new Plant Sample Submission App. Outreach events include workshops and tours held across the state where interactive adult learning methods are used in addition to traditional presentations. Montana Ag Live on Montana PBS is a call-in television program covering relevant agricultural and horticultural topics specific to Montana. Stakeholders highly appreciate the information provided by the IPM program, as illustrated by our outcomes, impacts, and the high level of support our program receives from organized stakeholder groups.

P12 Make a difference? Make an IPM impact graphic!

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The multidisciplinary Kansas State University IPM team develops and delivers information to stakeholders through several online platforms and other technological enhancements as

well as traditional face-to-face events and print materials. To understand project impact, we have used innovative evaluation strategies and graphical tools. For example, our evaluation team surveyed project leaders and stakeholders to define how these projects are increasing collaborations, including a social network analysis to depict where our work expands connections. The process included developing evaluation instruments, collecting data, and analyzing information in order to create graphic illustrations. We used maps to display project reach within Kansas and across the nation, based on program registrations (website and conference or meeting participation) and website analytics. We developed word clouds to highlight common themes among our multidisciplinary activities. We used a timeline to clearly show project growth and development over several years. A short booklet was developed using these program impact data to share with administrative stakeholders who have decision-making capacity related to funding IPM program funding. Overall, the evaluation process, data analysis, and creation of these *impact graphics* are essential for relaying the importance of our united IPM efforts through the Extension Implementation Program.

PI3 Regional IPM and IR-4 collaboration: Assessing pesticide compatibility in an IPM program

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The Inter-Regional Project #4 (IR-4) helps increase available pesticides for specialty crop producers by developing research data to support new product uses. Four Regional IPM Centers are competitively funded by USDA-NIFA to promote the development and adoption of integrated pest management in agriculture and non-agricultural settings. The Western Integrated Pest Management Center and the Western Inter-Regional Project #4 (IR-4) recently collaborated to develop the IPM Criteria Guidance tools, which are now used by IR-4 project requestors to evaluate the extent to which a proposed new pesticide use is compatible with IPM. The IPM Criteria Guidance includes instructions to help IR-4 project requestors develop an IPM ranking and an IPM Fit Statement for each project request. An evaluation of IPM fit statements from 2015 and 2016 demonstrates that the IPM Criteria Guidance has led to more comprehensive IPM Fit Statements. The quality of the statements has improved, and many statements now include the impact of the pesticide use on beneficial species, the targeted use of the products, and the role of the pesticide in resistance management. In a survey of all 2015 Western IR-4 project requestors (n=16, 53% response rate), 75% agreed that the IR-4 program should consider IPM fit as a component of IR-4 project applications, and 50% said the process was beneficial to them in developing their requests. The IPM Fit Statements are used in the IR-4 Food Use Workshop to help prioritize projects, and will be used when IR-4 submits data packages to the Environmental Protection Agency.

PI4 Doctor of Plant Health: Optimizing IPM for maximal impact

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Numerous reports indicate that agriculture must double its production by the year 2050 to feed the projected world population of 9 billion people. This challenge also comes with the expectation that this is done sustainably. To accomplish this momentous task, consumers, producers, and researchers across disciplines will need to work together to develop and implement IPM programs more effectively into production systems. The Doctor of Plant Health (DPH) program at the University of Nebraska–Lincoln aims to educate practitioners with the capacity to accomplish just that. Students in the DPH program build relationships with scientists and producers within these and other disciplines to form a wide, stable foundation. Similar to other professional doctoral programs (e.g. MD, DVM), DPH practitioners apply the knowledge and technology from researchers in various disciplines, ranging across plant science, soil science, weed science, entomology and plant pathology. DPH graduates use a holistic approach to form and implement sustainable, integrated management strategies into complex plant systems. The Doctor of Plant Health program provides a critical vision for solving the grand challenges brought on by the world food crisis.

PI5 Success of interdisciplinary professional doctoral programs

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The Doctor of Plant Health (DPH) Program at the University of Nebraska–Lincoln, and the Doctor of Plant Medicine (DPM) Program at the University of Florida are interdisciplinary professional programs designed to educate high-level practitioners capable of managing across entire plant productive systems. With the relative newness of these programs—DPM founded in 1999 and DPH in 2009—it is especially important

to assess the employment experiences of their graduates. Surveys were sent to DPH and DPM graduates to assess the perceived value of their degrees, and to employers to assess their perception of the programs' graduates. Thirty-six out of 76 graduates and nine out of 15 employers responded to the surveys. Of the survey participants, 100% of the DPH and 81% of the DPM graduates were employed full time, whereas 9.5% of DPM graduates were employed part-time, and 9.5% of DPM graduates were self-employed. As a result of the program, there was a significant increase in the graduates' confidence across all contributing disciplines. Ninety percent of graduates indicate their degree either somewhat or very likely influenced their hiring. Overall, graduates noted a 93.3% satisfaction rate in their employment, with employment occurring across multiple business sectors (agriculture and horticulture industry, university extension and teaching, consulting, contract research, government). Employers also responded favorably to the concept of hiring other graduates with these degrees. This survey demonstrates the success of graduates from these programs and the increased demand for practical interdisciplinary education.

P16 Organic and IPM Working Group

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A great challenge of the 21st century is the need to feed a growing population while improving the productivity of agricultural ecosystems and the health and integrity of surrounding environments for future generations. Integrated pest management (IPM) and organic production methods can work together to address this vital challenge. These two groups share broadly overlapping interests in environmentally conscious food production, yet few opportunities exist for cross-pollination of ideas between them. The Organic and IPM Working Group poster provides an overview of the group's history, mission and projects. The group's goals include illuminating ways that organic and IPM can work together for further inquiry, discussion and action leading to increased adoption and growth of sustainable production systems. We have developed several publications detailing the challenges these two communities face and opportunities for collaboration, including a white paper, fact sheet, issue of IPM Insights, and a collaborative position paper. In addition to these publications, the group has also participated in and provided feedback about several important programs involving the organic and IPM communities, including regional and national priority setting meetings for the IR-4 program and federal conservation agencies to address barriers facing organic and IPM growers. We invite you to visit our website for more information and links to our publications. Please contact Ali Loker, working group coordinator or Tom Green, working group co-chair, with any questions.

P17 Vermont's Extension IPM program addresses diverse stakeholder needs

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The Vermont Extension Implementation Program (VT EIP) uses an interdisciplinary approach to address critical IPM needs identified by Vermont and New England stakeholders by providing current and emerging IPM information to commercial growers and consumers to encourage adoption of effective, affordable and environmentally-sound IPM practices. The VT EIP team includes specialists in plant pathology, entomology, horticulture, agronomy, pesticide education, weed science and community outreach. An EIP coordinator and an evaluation specialist also play critical roles in Vermont's program, maximizing communication and cooperation among Priority area teams to ensure effective programs and impacts.The goal of the VT EIP is to develop and promote effective education and outreach programs to increase adoption of IPM tools by both new and established growers and consumers that reduce pesticide use, reduce pest and disease losses, decrease production costs and reduce human and environmental risks. Current IPM information coupled with effective outreach is vital to Vermont's agricultural and urban communities and promotes increased adoption of IPM practices in a wide range of crops and settings while reducing risks to human health and the environment.

P18 Nebraska Extension Team: Protect beneficial insect ecosystems including pollinators

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Nebraska Extension established a new statewide issue team—Protect beneficial insect ecosystems including pollinators. During 2017 Nebraska Extension Specialists and Educators met with representatives from state and federal agencies, non-profit organizations and industry to gather input into a Beneficial Insects Protection Plan for Nebraska. This plan will identify action steps that solidify stakeholder partnerships and identify knowledge gaps that will inform research and improve best management practice guidelines. Some of our desired outcomes include: Citizens will gain knowledge and adopt practices that enhance ecosystem functions and improve pollinator health and resiliency, Ag professionals will

adopt conservation practices/strategies that enhance profitable and environmentally resilient ecosystems. Our approach will include:

1. Enhance or restore pollinator habitats and forage in rural and residential Nebraska.

2. Promote communication to foster cooperative relationships and amicable co-existence among beekeepers, growers, homeowners, pesticide applicators, industry, and regulatory authorities.

3. Identify practices and crop-specific mitigation actions to reduce pesticide exposure and risk to pollinators with minimal time, labor, or economic burden to parties.

4. Promote the reduced use and need for cosmetic pesticides.

5. Continued high label compliance and effective use of pesticides to promote productive agricultural industry.

P19 Nebraska Extension Resistant/invasive Issue Team #IRPESTS

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In 2015 Nebraska Extension surveyed stakeholders, extension staff and faculty to gauge, what was considered, critical issues within the state; eighteen issues were defined. Multi-disciplinary teams were formed to create demand-driven, focused content on the specific issues prevalent in the state. One issue team Resistant/Invasive Pests has an interdisciplinary team consisting of: agronomists, entomologists, pathologists, horticulturists, community vitality specialists, integrated pest management specialists, pesticide safety education specialists, and soil scientists. In 2017 the team wanted to evaluate the impact it has had in two years of education and training on invasive/resistant pests. A general knowledge survey was developed. This survey includes: (1) general knowledge questions on invasive/resistant pests, (2) photo identification of invasive/resistant/beneficial species, and (3) practices of integrated pest management. This survey was first initiated to the general public, during the Nebraska State Fair, to establish a baseline. Fair goers were asked to take the survey, with Extension Educators on hand to help answer missed questions and respond to questions about invasive/resistant pests. The next step is to administer the same survey to clients who have gone through training administered by our programs (i.e. Crop Production clinics, Extension Master Gardener Volunteer programs, Pesticide Applicators classes. etc.) The baseline results show the general public is unclear of plant and insect identifications, both beneficial and invasive species, and they are also unsure of good IPM practices. We will compare the two sets of surveys to find our strengths and weaknesses in programming, allowing us to then align our training in the best methods.

P20 Lessons learned and best practices for developing IPM online trainings

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Traditional top-down extension of information via experts has become just one of the many sources of online information that is available to people. It is important, now more than ever, to provide information in a way people want to receive it. Cooperative Extension is beginning to see the benefits of using online trainings as part of their outreach programs. While a narrated PowerPoint presentation with added quiz questions is an online training, it is not ideal for motivating participants and facilitating their learning. UC IPM's first online training in 2011 followed this format. Since then, our goal is to make the experience interactive—and dare we say—entertaining. We accomplish this by following good instructional practices, such as developing and strictly following learning objectives, and ensure all activities (e.g., exercises, videos, animation, and quizzes) have a purpose. Initial evaluation results show that we are accomplishing this. Once you have your online training, where it is hosted is important too. An analysis of 20 different learning management systems and hosting options showed that LearnUpon provided the most benefits; LearnUpon provided great customer service and was intuitive to use for both learner and administrator. In the end, eXtension will host UC IPM's online courses, primarily because it is free for UC IPM to use. Our next goal is accessible online courses. We are working to understand how to apply the rules, learning the tools to test for accessibility, and determining what accessibility will mean for our ability to include interactive elements.

P21 Arkansas mini-grants—A county-based IPM program

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Integrated pest management (IPM) faces many obstacles including multiple sources of information, commodity prices, etc. The Arkansas mini-grants ipm program is a county based program in which funding is provided to county agents in row crop counties to support IPM programming. Arkansas has at least one county agent in every county. Agents submit proposals for funding to an IPM committee each year. Arkansas is a diverse state in which clientele in different areas deal with different pest problems. This approach allows programs to be tailored to the specific need of local clientele. County proposals include demonstrations, outreach and a budget. Agents are

required to submit a report at the end of the growing season in order to be considered for further funding in the future. The IPM committee is multi-disciplinary with specialists in the areas of entomology, plant pathology, weed science and agronomy. The committee does give some guidance by providing a list of focus areas for agents to utilize. The program has been successful with 20+ counties submitting proposals on a yearly basis. Information from these programs are extended to clientele through newsletters, radio, social media, county field tours and county production/IPM meetings.

P22 North Dakota State University Extension pest management app

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North Dakota State University (NDSU) Extension service publishes three pesticide guides; herbicide, insecticide, and fungicide/nematicide. These guides contain information on pesticide use rates, efficacy, application timing, and other critical information for effective integrated pest management. Approximately 9,000-20,000 printed copies of each guide are distributed annually. To meet the demands of modern technology, a smart device application was developed that houses information from all three pesticide guides in one platform. With support from North Dakota crop commodity groups, the NDSU Pest Management App was launched in 2013 and now includes pesticide information for 10 field crops; chickpea, corn, dry bean, field pea, lentil, potato, small grains, soybean, sugarbeet, and sunflower. A photo submission tool was added to help with pest identification in 2016. The use of the photo submission tool has quadrupled since its inception. Other tools that have been incorporated or that will be incorporated are pesticide efficacy tables, a calendar link to Extension events, and a pest photo library. The NDSU Pest Management App is a dynamic tool that has been downloaded over 6,800 times on iOS and Android smart devices and provides important up-to-date pesticide information for agricultural professionals in North Dakota.

P23 Virtual plant clinics cultivate new ideas and collaborations

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Plant clinics, in-person workshops in which Extension personnel shared samples, experiences and information about growing conditions in the field, were once common in Extension. Today, the availability of online technology makes it possible to offer "virtual" plant clinics (VPCs). During the 2017 growing season, VPCs were established by University of Maryland Extension (UME) educators and specialists. Three clinics were held: one in July, August and September. Clinics were hosted using the web-based teaching platform, WebEx, and participants were granted access to a Google Team Drive where they could upload and submit their own photographs for discussion. In addition, VPCs were recorded for later viewing and future reference. During the VPCs, each participant had the opportunity to share pictures and discuss field conditions. A survey at the end of the season was completed by 21 Agriculture Educators and/or Specialists. Participants indicated the top reasons they attended the VPCs was to learn what others were experiencing in the field (85%) and to learn more to share new knowledge (69%). A majority (85%) felt that they were more likely to attend a VPCs over an in-person clinic, and 84% of respondents would like to see VPCs offered in the future. As a result, UME plans to continue offering VPCs as a way for educators and specialists to communicate and share ideas throughout the growing season and facilitate communication and collaboration between UME faculty and neighboring institutions. Ultimately, crop loss can be reduced, helping to ensure farm profitability.

P24 Maryland invasive training and outreach programs

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Educational training and outreach programs on identifying new pests have been the focus of Maryland Extension invasive training programs for the National Plant Diagnostic Network (NPDN) and the Sentinel Plant Network (SPN). Maryland is a diverse state in geography with plant species (both southern and northern native flora) and therefore susceptible to invasive pest introductions from northern and southern sources from interstate transport of goods as well as coastal ports, rail lines and airports. Training efforts have included

hands-on workshops, development of smart phone and tablet apps, invasive pest posters, and ID card sets for extension, federal and state personnel, master gardeners and green industry audiences. Presentations have included information on emerald ash borer, Asian longhorned beetle, lantern fly, exotic bark beetles, Sirex woodwasp, Japanese longhorned beetle, boxwood blight, thousand cankers disease, oak wilt, chrysanthemum white rust, *Ralstonia solanacearum*, and *Phytophthora ramorum*.

P25 not being presented

P26 Worker Protection Standard for organic and small farms

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Organic farmers and other farmers who choose not to use Restricted Use Pesticides may not realize that Worker Protection Standard requirements apply to them. However, any farmer who uses WPS-labelled products, which include many organic pesticides, is responsible for following labelled Restricted Entry Intervals, using at least the labelled Personal Protective Equipment, keeping emergency wash supplies available, annually training farm-workers, and notifying workers about pesticide applications. Extension programs have a role to play in helping organic and small farms understand the Worker Protection Standard and farm safety practices.

P27 Pesticide Risk Tool: Reducing and reporting pesticide risks in IPM and sustainability initiatives

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Pesticides are critical tools for food and fiber production. Pesticide risks are real but can be carefully managed to minimize adverse impacts. Much progress has been made to reduce pesticide risks, including many new reduced-risk products and proven mitigation strategies, and ready access to this information will help reduce adverse impacts and improve environmental stewardship. The Pesticide Risk Tool is an innovative on-line tool for growers, advisors, IPM and sustainability program managers and others to evaluate pesticide products and uses for impacts on soil, water and air quality, avian and aquatic life, beneficials including pollinators, and worker and consumer health and safety. The tool applies the best available science to identify options with the fewest potential environmental and health risks, identify mitigation options for products/uses selected, and estimate/report progress in reducing risks. By providing ready on-line access with a farmer-friendly interface and addressing a comprehensive set of resource concerns, the Pesticide Risk tool offers advantages over alternative systems including the Environmental Impact Quotient and the US Department of Agriculture Natural Resources Conservation Service Windows Pesticide Screening Tool. The Pesticide Risk Tool is currently in use in major multinational food company initiatives in the US at www.pesticiderisk.org.

P28 Green Shield Certified and IPM STAR pest management certification programs

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Green Shield Certified is an independent, award-winning, third-party certification program that promotes practitioners of effective, prevention-based pest control while minimizing the need to use pesticides. The program uses a rigorous, on-site evaluation to verify policies, practices and products to meet a high standard for IPM. Green Shield Certified offers certification for pest management providers, structural pest management programs and facilities, other than schools. Certified businesses and buildings are dedicated to effective IPM practices with the least risk to people and the environment. Green Shield Certified currently certifies 36 service providers, programs and facilities, and continues to be contacted by many pest control professionals and facility managers interested in becoming certified.

IPM STAR certification program recognizes and rewards IPM practitioners who meet a high standard for IPM in schools, childcare centers and youth services facilities. The program uses a rigorous, on-site evaluation of policies, practices and conditions, similar to that of Green Shield Certified. More than 2 million children have benefited from reductions in pest problems and pesticide use since 2003. IPM STAR recently certified four new school districts in Texas, in cooperation with both Janet Hurley, Texas A&M AgriLife Extension Service, and Shakunthala Nair, University of Arizona. Green Shield Certified and IPM STAR are operated by the IPM Institute of North America, a 501(c)3 nonprofit organization recognized by the U.S. Environmental Protection Agency for its expertise and accomplishments in promoting integrated pest management. The purpose of both certification programs is to promote the practice of effective, prevention-based pest control that minimizes the use of pesticides, to recognize and reward IPM practitioners who meet a high standard for advanced IPM and to improve the health of occupants and the environmental health of facilities, including school children and schools.

P29 The Sustainable Food Group introduces the Sustainability Standard

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The Sustainable Food Group, a project of the IPM Institute, focuses on enhancing the development of sustainable agricultural practices and incorporating them into IPM. The goal of the project is inform the public about IPM and the benefits that it presents to both suppliers and consumers. The Sustainable Food Group worked with Sysco during the development of the Sysco IPM program and is responsible for facilitating biannual conference calls to uphold the prestige of the program as well as maintain a presence at Sysco supplier conferences. With the success of the Sysco Sustainable/IPM Program, producers have expressed the need to similarly document and report their performance to buyers and others, including in conjunction with food safety audits. In response, we are working with the Azzule Systems™ and PrimusLabs™ to develop a third-party sustainable agriculture certification—the Sustainable Food Group Sustainability Standard™. The Sustainable Food Group's poster will give brief overview of the history of the development of the Sustainability Standard as well as what it will be applicable to in order to inform practitioners and potentially interested parties. Please contact Christian Steponitis, Symposium Organizer, or Ali Loker, Sustainable Food Group Manager, with any questions.

P30 Adoption of proactive resistance management practices to control *Bemisia tabaci* in Arizona and California

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In Arizona and California whiteflies (*Bemisia tabaci* MEAM1) are an important cross-commodity pest. With an increase in costs associated with the production and marketing of new chemistries there remains a limited number of chemistries available to control this pest. As resistances continue to evolve in whitefly populations, behaviors must be changed to preserve the effectiveness of available controls. Over a two-year period in 2015 and 2016 whitefly populations were collected from cotton fields in Arizona and California. Susceptibility of collected populations to the six major whitefly modes of action was measured with bioassays. These bioassay results were compared with current and previous year section-level insecticide usage data to determine relationships between both local and regional chemical usage patterns in whitefly crops and the spatial and temporal association of such usage patterns in resistance dynamics. Throughout this project pest managers were educated on the principles of resistance management and the usage patterns in their areas of responsibility. Whitefly insecticide usage maps were instrumental in educating the pest managers on their collective usage patterns at the section-level. This research gives decision makers the tools to support them in reducing selection pressures and enhancing resistance management. These tools allow resistances to be proactively managed through educated pesticide choices and an improved understanding of the spatial and temporal dynamics of resistance development. Using pesticide usage data, surveys, and interviews we can determine the level of adoption and success of the project to educate decision makers on the tools available to manage resistances.

P31 Minimum risk pesticide active ingredient profiles

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The US EPA determined that certain Minimum Risk Pesticides (MRP) pose little to no risk to human health or the environment, and so exempted them from the registration requirements in the Federal Insecticide, Fungicide, and Rodenticide Act. Starting in 1996, the EPA exempted such products to reduce the cost and regulatory burdens on businesses and the public for pesticides posing little or no risk, and to focus their resources on pesticides that pose greater risk to humans and the environment. EPA designated 31 substances as eligible to be active ingredients in MRPs. Many of these are either commonly consumed foods or 'Generally Recognized as Safe' food additives, such as cinnamon oil, garlic, and corn gluten meal. The MRP exemption probably encouraged their development and sales, but information on uses, efficacy and safety is often disparate and difficult to find. Such information is sought by potential end-users as well as regulators. For these reasons, we produced profiles of the 31 active ingredients that are allowed in minimum-risk pesticides. We present information on pesticidal uses, physical and chemical properties, human health effects, environmental effects, efficacy, and standards and regulations that apply to the active ingredient. The profiles are intended to help officials, practitioners, and the public to better understand the risks and benefits of the active ingredients in MRPs. The profiles were created at the request of the New York State Department of Environmental Conservation, and are available for free on the NYSIPM website, https://ecommons.cornell.edu/handle/1813/52630.

P32 Repeated temporal rotation from nontoxic bait to a cholecalciferol rodenticide enhances control of a wild house mouse population

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Commensal rodents including the house mouse (*Mus musculus* L.) continue to pose a serious risk of damage and disease in agricultural systems, confined animal facilities, and food storage facilities. Control of *M. musculus* and other commensal rodents rely heavily on the use of rodenticides often placed within bait stations. Adequate acceptance of rodenticides is essential for successful control and can be negatively impacted by behavioral resistance factors such as neophobia, conditioned taste aversion, and competitive exclusion. To gain a better understanding of how these problematic factors may impact control of a wild *M. musculus* population, parameters including frequency of bait station visits, bait consumption, and population demographics were monitored during a temporal baiting rotation. The schedule for this temporal rotation consisted of two rotations progressing from empty stations to nontoxic bait and ultimately a cholecalciferol rodenticide. The repetitive nature of this baiting schedule allowed for initial bait acceptance and behavior to be compared to levels when baits were reintroduced for both nontoxic and cholecalciferol baits. Results indicated that during the initial cholecalciferol phase consumption declined significantly from nontoxic levels and failed control was attributed to a loss in consumption. Consumption immediately rebounded with the reintroduction of nontoxic bait and when cholecalciferol was returned, consumption trends were similar to the original baiting, increasing overall efficacy.

P33 Entomotoxicant potential of *Croton penduliflorous* extract for the control of the subterranean termite *Macrotermes subhyalinus*

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Termites are insect pests known for causing economic damage to wood, wood products, as well as green standing plants. Many botanicals have proven to be insecticidal to termites. However, there is a continuing need to find additional plants with insecticidal properties. *Croton penduliflorous* is a medicinal plant with seeds known to have toxic properties and efficacy on *Macrotermes subhyalinus* was assessed. Efficacy of pulled fractions of oil extract of *C. penduliflorous were tested* against *M. subhyalinus* termites under laboratory conditions at 28 ± 2°C and 70± 5% relative humidity. The oil extract of the plant was fractionated into different fractions using column chromatography, the fractions were pulled together and tested against termites at 0 (control), 2, 4, 6 and 8% concentration levels. Ten insects were introduced into containers having the different concentration levels and were replicated four times. The number of dead insects was recorded after 1, 4, 8, 12 and 24 hours. The pulled fraction was characterized using spectroscopic techniques. Results showed that mortality and repellency of *Macrotermes subhyalinus* was dose dependent. At low concentrations of the fraction, 50 and 95% insect mortality was achieved within 24 hours (LC_{50} and LC_{95} for concentrations of 4.18% and 19.62%. Characterization of the pulled fractions indicated the presence of tannin as the active ingredient. The result obtained showed that *C. penduliflorous* oil has high insecticidal activity, and has potential as a termiticide.

P34 Protecting water resources with on-farm pesticide rinsate biobeds: A Canadian perspective

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As environmental contamination and water scarcity are mounting issues while the world population keeps growing, protecting water resources is crucial. The agricultural sector is the most important user of water and pesticides around the world. Surface and ground water contamination by pesticides has been linked, among others, to pesticide handling areas on farms. On-farm pesticide rinsate biobeds are structures designed to remove pesticides from sprayers' rinsate, where the rinsate is filtered through a mixture of straw, compost and soil ("biomixture"). Although used in Europe for decades, biobed use in North America is lagging behind and requires adaptation from European models due to cooler temperatures and different use of pesticides prevailing in North America. We describe the use of five biobeds in the Prairie region of Canada, their pesticide removal efficiency as well as challenges. Biobeds received up to 51 different pesticides annually through their influent, and removed on average 96% of the mass of active ingredients applied. Three pesticides recalcitrant to removal were identified: clopyralid, bentazone and imazapyr. Single-cell biobeds performed as well as double-cell (serial) biobeds under the various pesticide use regimen and climatic conditions. Embedding heating device in biobed extended the

period of use in spring and fall by maintaining favorable biomixture temperature for microbial activity. No significant decline in pesticide removal efficacy was observed over a two year-period. Overall, results indicate that pesticide rinsate biobeds are an efficient and practical option for Canadian growers to reduce the risk of water contamination by pesticides at the farm.

P35 The Prairie Pest Monitoring Network: A coordinated monitoring of field crop pests of the Canadian Prairies

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The three Canadian Prairie Provinces (Alberta, Saskatchewan, and Manitoba) account for over 52 million hectares of farmland, with large areas annually seeded to canola (oilseed rape), wheat, pulses, and specialty crops. Invasive and endemic insect pests associated with these crops have potential to cause significant crop yield and quality losses. Area-wide monitoring of pest populations, and of natural enemies populations, is a cornerstone of integrated pest management that is often overlooked or omitted. To guide crop selection, agronomic practices, and in-field scouting efforts to support informed decision-making for pest control, a coordinated monitoring program was developed in the prairies. The Prairie Pest Monitoring Network (PPMN) conducts and compiles data from annual pest surveys and uses abiotic data (including wind trajectories), to provide weekly updates on insect activity during the growing season and produce annual distribution and forecast maps. This information is communicated to industry stakeholders using a variety of technology transfer vehicles, including the Prairie Pest Monitoring Network Blog. Information generated by the PPMN alerts growers to emerging pest issues, areas of potentially high pest pressure, and raises the profile of natural enemies and their role in pest management. The Network has also developed protocols for insect pest monitoring and scouting (available on-line) and works to develop predictive models for key insect pests to assist the industry manage issues related to climate change, new agronomic practices, and new crops. Here we present the 2017 forecast and distribution maps for six pests of oilseeds, wheat, and pulses in the Canadian Prairies.

P36 Illustrating the benefits of a strategic approach to reduced risk pest management: The case of foliar insect pests of prairie field crops in Canada

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Since 2003, the Agriculture and Agri-Food Canada's Pesticide Risk Reduction Program has been collaborating with grower groups, provincial crop specialists, public sector researchers and industry stakeholders to develop pest management strategies which help growers reduce risks associated with the use of chemical pesticides in agricultural crop production. To date the Program has developed 17 strategies addressing several priority pest issues in many agricultural crops which have contributed to increased grower access to new knowledge and alternative pest management tools and practices compatible with IPM systems. The new knowledge and pest management practices have been developed and demonstrated to growers through numerous projects funded by the Program in the context of these strategies. Here we illustrate the benefits of this strategic approach by presenting the case of the Program's Strategy for Reduced Risk Management of Foliar Insect Pests of Prairie Field Crops. Initiated in 2011, this strategy was selected for work by the Program because of concerns regarding impacts of insecticides used over large acreage and the overuse of single classes of insecticides contributing to development of pest resistance to chemical products. Targeting mainly insect pests of cereals, canola, and alfalfa among other crops, this strategy is helping to reduce reliance on insecticides and support sustainable crop production on about 52 million hectares of prairie farmland in Canada. Various IPM tools and practices resulting from the strategy work over the past 7 years in the areas of pest monitoring and forecasts, management decision making and biological control approaches, will be presented.

P37 Cereal Aphid Manager: A dynamic action threshold smartphone application for scouting cereal aphids

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Cereal aphid populations can increase rapidly and exceed economic thresholds resulting in yield loss in wheat and other cereal crops. Aphid natural enemies however, have the capacity to keep aphid populations from reaching economic

thresholds. Two main species of aphid are typically present in cereal crops on the Canadian Prairies, English grain aphids, *Sitobion avenae* Haliday and Bird-Cherry Oat aphids, *Rhopalosiphum padi* (L.) (Hemiptera: Aphididae). Common natural enemies are in the families Anthocoriidae, Aphidiidae, Aphelinidae, Coccinellidae, Chrysopidae, and Nabidae. A computer model that incorporates the life history of predators and aphids was constructed to predict population growth of aphids and predation by natural enemies as identified in field surveys. The model uses a dynamic action threshold (DAT) and will recommend an insecticidal treatment if the economic threshold will be exceeded, or no treatment with continued monitoring, if existing predators are expected to suppress aphid population growth below the threshold. The DAT is incorporated into the Cereal Aphid Manager smartphone application built for the iOS and Android platforms and a beta-test validation exercise was conducted under field conditions in summer 2017. This smartphone application will be made available for use to cereal growers, scouts and crop advisors as an integrated pest management (IPM) tool that supports effective scouting and informed decision making approach with the potential to eliminate unnecessary use of pesticides to control aphids in cereal production. The results of application performance during the 2017 field validation will be presented.

P38 Integrated management of wheat midge infestations in wheat crops of Western Canada

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Wheat is Canada's largest crop with about 14 million ha of area seeded, 30 million tonnes of wheat produced and wheat export revenues of about CAD$ 5.5 billion annually. Wheat midge, *Sitodiplosis mosellana* (Géhin) (Diptera: Cecidomyiidae) is an invasive alien species introduced into North America in the early 1800s. However, wheat midge emerged as a major pest in 1983, when wheat growers in northeast Saskatchewan experienced losses in excess of CAD$ 30 million. By early 1990s, crop losses due to wheat midge reached CAD$ 130 million. Today, while wheat midge is still a major pest of spring wheat, durum wheat and triticale in most wheat growing areas of Canada, growers have access to a comprehensive and successful integrated pest management (IPM) program developed over the past 20 years. This IPM program has been successfully adopted by wheat producers, in large part due to the technology transfer efforts of researchers and provincial entomologists. As a result, this IPM program has led to lower pest pressures and fewer pesticide sprays, thus reducing the economic and environmental impact of wheat midge management. For example, the value of biological control, due to savings in insecticide costs alone, was estimated to be over CAD$ 248 million in the 1990s. Here we present key elements of this IPM program and tools developed, including decision support systems such as forecasts, risk warnings and thresholds, resistant wheat varieties, and biological control, as well as how these benefit growers in the sustainable management of wheat midge in their crops.

P39 Baseline regulation of key genes in the phenylpropanoid pathway and their role in defense against biotic stresses in Maize

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Maize is a major constituent of human and animal diets, an important model organism for genetic research, and a sustainable source of biomass for the production of second generation biofuel. The engineering of cell wall composition for increased biofuel production, in the form of modified lignocellulose, has been a promising strategy to more efficiently convert plant biomass to biofuels. Despite these efforts, few studies have demonstrated how the modification of lignin content in cell wall affect the incidence of insect herbivory and pathogen severity. In order to characterize the effects of these biotic stresses, we mined public databases of Maize gene expression to focus specifically on genes involved in the phenylpropanoid pathway. With an interest in both the expression of the inbred B73 cultivar and numerous phenylpropanoid pathway mutants, we collected gene expression data related to lignin production focusing on two main enzymes: caffeic-acid-O-methyltransferase (COMT) and cinnamoyl alcohol dehydrogenase (CAD). The overall gene expression for these two genes was low during normal growth. However, variation in gene expression in other phenylpropanoid genes was observed among different treatments and conditions, suggesting that this pathway is highly plastic. This study will provide information regarding the underlying process of gene expression of engineered plants for biofuel production. Additionally, it will enable researchers to engineer plants resistant to pests for sustainable pest management practices.

P40 Antixenotic potential in pulses against the pea aphid *Acyrthosiphon pisum* (Harris)

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Pulses, the large-seeded species of legumes (Fabaceae), are grown mainly as a source of plant proteins for human and animal consumption but they function also as natural fertilizers due to their ability to fix atmospheric nitrogen. Currently, grain legumes are a major part of many people's diet worldwide and an important element in peoples' food security, especially in semi- and arid climates. The feeding activities of sucking insects combine two kinds of harmful effects on plants: the feeding affects plant condition directly due to the removal of nutrients and/or the otherwise interference with plant physiology, and, indirectly, by contributing to viral diseases dispersal. The pea aphid *Acyrthosiphon pisum* (Harris) alone is able to transmit over 40 different plant pathogenic viruses. Due to its worldwide distribution, *A. pisum* is considered one of the most important pest insects of leguminous plants. One of the alternative methods to the use of insecticides is the exploitation of the natural or bred traits that enable plants to defend themselves against herbivores. The aim of the present work was to determine the existence and the localization of the potential antixenotic factors in different tissues of eleven species and cultivars of grain legumes. We applied the technique of electronic monitoring of aphid probing known as EPG. We discussed the results in respect to inter- and intraspecies variation in susceptibility to the pea aphid infestation and the probability of virus transmission to and from these plants in non-persistent, semi-persistent and persistent ways by *A. pisum*.

P41 Susceptibility of small-seeded legumes to infestation by pea aphid *Acyrthosiphon pisum* (Harris)

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A 'legume' is the common name used for plants of the family Fabaceae (=Leguminosae), also called bean or pea family. The great diversity and ubiquitous distribution of legumes make them not only important components of various ecosystems but also the second, after grasses (Poaceae), economically and agriculturally important plants. For practical reasons, legumes are divided into two groups basing on the seed size: large-seeded legumes and small-seeded legumes. The small-seeded legumes are used as important forage crops for grazing animals and to improve soil organic matter and contribute nitrogen to succeeding crops in crop rotation systems. The pea aphid *Acyrthosiphon pisum* (Harris) (Hemiptera: Aphididae) is globally distributed throughout all temperate regions of the world but it has become an important pest on legumes also in tropical regions of Africa. *A. pisum* is known to transmit more than 40 plant viruses in non-persistent, semi-persistent and persistent ways. The aim of the present study was to assess the level of susceptibility of fifteen small-seeded legume species and cultivars to the infestation by *A. pisum*. Basing on EPG (Electrical Penetration Graph) monitoring of the pea aphid behavior during penetration in plant tissues, we were able to distinguish taxa that are unacceptable, partially acceptable, and acceptable for *A. pisum*. We discuss the results in respect to the risk of direct damage to the plants, the probability of virus transmission to other crops, and the probable role of these plants as sources of winged migrants in agroecosystems.

P42 Integrated management of glyphosate-resistant horseweed [*Conyza canadensis* (L.) Cronq.] with tillage and herbicides in Nebraska soybean (*Glycine max* (L.) Merr.)

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The widespread adoption of reduced tillage practices and heavy reliance on single modes-of-action herbicides in the past couple of decades have resulted in the evolution of herbicide resistant weeds, including glyphosate-resistant horseweed [*Conyza canadensis* (L.) Cronq.], in the Midwestern United States. A field study was conducted in 2015 and 2016 to determine an integrated effect of tillage and/or herbicide programs for management of glyphosate-resistant horseweed in Lincoln, Nebraska, USA. The contrast analysis suggested that fall tillage provided greater (97 to 99%) control and density reduction of horseweed compared to fall burndown applications (91 to 95%) at 14 and 18 weeks after applications. Similarly, horseweed management programs included with spring tillage provided 88 to 99% control and density reduction compared to spring and fall burndown applications (67 to 92%) at 4 weeks after spring applications till soybean (*Glycine max* (L.) Merr.) harvest; however, spring and fall tillage provided similar (82 to 99%) control throughout the season based on contrast analysis. At 3 weeks after post-emergence applications, horseweed control or density reduction was 82 to 99% with fall or spring tillage either applied alone or followed by pre-emergence-only, post-emergence-only, or pre-emergence followed by post-emergence herbicides. However, fall or spring burndown followed by pre-emergence -only, post-emergence-only, or

pre-emergence followed by post-emergence herbicides provided 71 to 99% control and density reduction compared to 14 to 51% with fall or spring burndown applied alone at 3 weeks after post-emergence applications. The contrast analysis suggested that horseweed management programs included with spring tillage provided greater soybean yield (1,237 kg ha^{-1}) compared to programs included with fall tillage, and fall or spring herbicide burndown (906 to 1,138 kg ha^{-1}). The results of this study suggest that integrated management programs including tillage and different site of action PRE and POST herbicides are available for GR horseweed control and need to be followed to reduce the evolution of herbicide-resistant weeds.

P43 Tools are available for integrated management of glyphosate-resistant common ragweed (*Ambrosia artemisiifolia* L.) in Nebraska soybean

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Common ragweed is an early emerging weed in Nebraska, USA and is competitive with soybean. Glyphosate has been widely applied in glyphosate resistant-soybean as preplant burndown and post-emergence for common ragweed control; however, the evolution of glyphosate-resistant common ragweed in Nebraska necessitates alternate and integrated control practices. Field experiments were conducted during 2014 to 2016 in a grower's field infested with glyphosate-resistant common ragweed in southeast Nebraska. The influence of tillage on common ragweed emergence pattern was evaluated as well as the efficacy of herbicide programs in glufosinate-resistant soybean. Total common ragweed emergence was not effected by spring tillage timing. Common ragweed emergence pattern was driven by soil thermal time with a base temperature of 3 C and was not affected by spring tillage or soil moisture content. Several preplant herbicides containing glufosinate, paraquat, 2,4-D, dimethenamid-P, cloransulam-methyl, or high rates of flumioxazin plus chlorimuron-ethyl resulted in 90-99% control of glyphosate-resistant common ragweed at 21 days after treatment (DAT). Effective preplant herbicides followed by glufosinate alone or in tank-mixture with imazethapyr, acetochlor, or S-metolachlor controlled glyphosate-resistant common ragweed 84–98% at harvest, reduced common ragweed density (≤ 20 plants m^{-2}) and biomass by ≥ 93%, secured soybean yield 1,819–2,158 kg ha^{-1}, and obtained the highest gross profit margins US$373 to $506. Spring tillage does not delay or stimulate additional common ragweed emergence; therefore it can be used in conjunction with effective preplant followed by post-emergence herbicide programs in glufosinate-resistant soybean for control of glyphosate-resistant common ragweed.

P44 Diagnosis of diseases caused by *Diaporthe* (*Phomopsis*) species on soybean in the United States

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Between 2014 and 2017, whole soybean plant samples consisting of stems, petioles and pods (*n*=123) exhibiting symptoms associated with diseases caused by species of *Diaporthe* (*Phomopsis*) were sent to the Oilseeds Pathology Lab at South Dakota State University by plant pathologists across 21 soybean producing U.S. states. Most plants exhibited reddish-brown lesions on the main stem, leaf petioles or pods. Seed within diseased pods appeared reduced in size and with a cracked seed coat. Using standard isolation procedures, three species of *Diaporthe* were isolated on potato dextrose agar, which were identified using morphological characteristics following a total of 21 days of incubation (color and colony appearance, size and shape of stromata, arrangement and shape of pycnidia and perithecia, and size of conidia) and DNA sequence analyses. Of the three species, *D. caulivora* and *D. longicolla* were isolated from stem, pods and seed of the diseased plants and accounted for 73% of the total isolates. However, *D. aspalathi* was recovered only from diseased stems and accounted for 27% of the remaining isolates. The specific surveys were undertaken in response to queries received from

researchers, crop consultants and soybean farmers regarding soybean diseases caused by species of *Diaporthe*. Rapid and accurate diagnosis is critical for the development of profitable and effective strategies to manage *Diaporthe*-related diseases.

P45 Comparison of a putative novel species of *Phytopythium* to other *Phytopythium* spp. for pathogenicity on soybean seed

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Phytopythium is a new genus in the *Pythiaceae* family that combines characteristics of both *Pythium* and *Phytophthora* spp. and several members are well known pathogens of soybean. Isolates of a putative *Phytopythium* novel spp. were collected in Wood county Ohio from symptomatic soybean seedlings. Sequence analysis of the ITS1 and ITS4 region were assembled and compared to NCBI database using BLAST, indicating only 90% similarity to a voucher specimen *Phytopythium boreale* CBS55188. The objective of this experiment was to compare this *Phytopythium* isolate to other *Phytopythium* spp. in the ability to cause seed rot damage on three soybean genotypes: IA3023, Sloan and Kottman. A seed plate assay was used to evaluate pathogenicity of 3 isolates of *Phytopythium* helicoides, 1 *Phytopythium* vexans, 1 *Phytopythium* litorale and 13 of the putative novel *Phytopythium* spp. in a growth chamber at 20°C in a randomized complete block design (RCBD) with three replicates. Data on seed rot damage was collected 6 day after the seed was placed on *Phytopythium* colonized PCA plates. A disease ordinal scale was used to rate disease severity from 0 to 3. Isolates Ppheli6 (*Phytopythium helicoides*) and Pp13 (*Phytopythium* novel spp.) were significantly more aggressive than the remaining isolates. Based on non-parametric analysis, cultivar Sloan (p-value = 0.0001) had the highest seed rot damage compared to IA3023 and Kottman. However, there was a significant isolate and cultivar interaction. Species of *Phytopythium* should be further evaluated to develop management practices to reduce seed rot diseases of soybean.

P46 not being presented

P47 Cropping intensity driven microclimate is influencing abundance of ground foraging predators in coffee farmlands

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Coffee farmlands in the Mt. Elgon region of Uganda are embedded in mosaic landscapes where the vast majority of natural forest and vegetation has been replaced by agricultural land to elevations of up to 2200 meters above sea level. The coffee is grown in different cropping intensities ranging from monoculture to food crop and shade tree inclusive systems. It has been established that inclusion of shade trees in coffee production in relation with elevation has contrasting effects on key insect pests of the crop. This study focused on soil foraging predators notably Carabidae, Formicidae, and Araneae. Carabidae and Formicidae were influenced by cropping intensity, elevation and the interaction of the two. Carabidae abundance increased with elevation for Coffee+Banana+Trees (mean counts = 34.07), Coffee+Banana (mean counts = 17.28), and Coffee+Annual (mean counts = 19.64) intensity but the reverse was true in the Coffee monocrop (mean counts = 19.40). Formicidae abundance also increased with elevation in the Coffee+Annual (mean counts = 16.46) and Coffee monocrop (mean counts = 16.06) but there was no particular trend for Coffee+Banana (mean counts = 5.48), and Coffee+Annual (mean counts = 5.30), which had the lowest counts. Araneae was only influenced by cropping intensity in the order Coffee+Annual (mean counts = 2.69), Coffee+Banana+Trees (mean counts = 1.70), Coffee monocrop (mean counts = 1.44), and Coffee+Banana (mean counts = 1.41). These trends can be partly explained by light intensity and soil temperatures of the farmlands as determined by cropping intensity per se or through interaction with elevation. As such, for specific predators, recommendations on appropriate coffee cropping intensities for farmlands at different elevations on the mountain slopes are possible.

P48 Biology-based strategies for integrated management of *Rhizoctonia solani* in soybean fields

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Rhizoctonia solani is a complex soil-borne pathogen species with 14 anastamosis groups (AG), which cause pre and post-emergence damping off in seedlings and are very difficult to manage. Fungicide seed treatments are used for managing the pathogen in soybean but are sometimes not effective or do not last through the season. Our objective was to develop biology-based strategies that are compatible with fungicide seed treatments for integrated management of *Rhizoctonia solani* in soybean fields. A highly virulent *R. solani* strain AG-4 HGII or a mildly virulent strain AG-3 were inoculated to different treatments in a soybean field. The field was subjected to nine treatments that include different commercially available biological products, plant growth promoting rhizobacteria (PGPR) strains, compost, and/or fungicide seed treatment in a randomized complete block design consisting of four replicates with 4 rows and 2.5 feet (30 cm) row spacing. All treatments were applied in furrow at the time of planting. The field was irrigated once per week. Plant stand was counted at V5-V6 growth stage. The plots were hand-harvested. Plots where fungicide treated seeds were planted with inoculation of a virulent pathogen or no pathogen had significantly higher plant stand than those without fungicide seed treatment. Plots with fungicide seed treatment followed by PGPR strains had significantly higher yield than those with no fungicide or biological treatment. Overall, biological products showed compatibility with fungicide seed treatment. Yields from plots with fungicide seed treatment were not different (p=0.1) from those with compost combined with biological products.

P49 The effect of fungicide application methods on foliar diseases, seed quality, and yield protection in soybean

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Soybean (*Glycine* max [L.] Merr.) is a major crop for meeting the increased demand for food, feed, fiber, and fuel. The ability to control foliar diseases is essential to ensure that soybean yields and economic returns remain high. The application of foliar fungicide is one method farmers use to manage these diseases. During 2017, field experiments in central Iowa were used to investigate how two different fungicide application techniques compare in terms of coverage, foliar disease control, seed quality, and yield protection. The two techniques tested were traditional, which was a ground applicator using XR11003 nozzles and undercover, which used XR11002 nozzles. Studies were conducted at two locations that consisted of a total of 34 replications and plots that were 5.3m and 15.2m long, with additional experiments planned for next year. Preliminary results showed a significant difference in coverage in the lower canopy when comparing traditional and undercover methods. However, no significant differences were observed for foliar disease severity, seed quality, and yield between treatments. This study will aid farmers in making IPM based fungicide application decisions that can provide the greatest return on investment.

P50 A meta-analysis and economic evaluation of soil and seed applied insecticide use in Indiana maize

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Neonicotinoid use in US maize has dramatically increased over the past decade, with virtually all US maize seeds treated with 0.25-1.25 mg of clothianidin or thiamethoxam prior to being sold to a grower. To compare the efficacy of the neonicotinoid seed treatment approach to previously used insecticides, meta-analyses were conducted on various plant health metrics from insecticide efficacy trials conducted at Purdue over a period of 15 years. Neonicotinoid seed treatments, in combination with fungicides applied to seed, were the only compounds to increase early season stand counts, suggesting a greater degree of early season protection. Other tested compounds did not consistently increase stand counts above that of the control. While an increase in stand was observed, all tested compounds performed similarly in increasing yield and decreasing corn rootworm damage, indicating a stand increase did not reliably result in a yield increase in the tested studies. The economic benefit of neonicotinoid seed treatments relative to other insecticides was also investigated. The economic analyses reported the probability of a grower monetarily breaking even under various input costs and market prices. The breaking even probability was >80% for all tested compounds under all sale conditions. These results indicate the utility of neonicotinoid seed treatments is about the same as previous insecticide classes in the tested metrics, with the exception of stand counts. This suggests that these compounds may be readily rotated with other compounds, providing benefits in terms of reducing non-target effects, environmental loading, and lowering resistance risk.

P51 Soil insecticide and insecticidal seed treatment impacts on timing of northern corn rootworm beetle emergence from *Bt* corn

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The northern corn rootworm, *Diabrotica barberi* Smith & Lawrence (Coleoptera: Chrysomelidae), is an economicaly important pest of corn, *Zea mays* L., in North America. Crop rotation, insecticides, and corn expressing *Bacillus thuringiensis* (Bt) proteins are used for rootworm management. The impacts of Bt corn, tefluthrin soil insecticide [Force® 3% granular; applied at 0.47 g (a.i.)/m in-furrow], and clothianidin insecticidal seed treatment [Poncho® 1250; applied at 1.25 mg (a.i.)/kernel] on the emergence timing of *D. barberi* beetles were compared in North Dakota corn. Hybrids expressing Cry3Bb1, Cry34/35Ab1, and pyramided (Cry3Bb1 + Cry34/35Ab1) Bt proteins were tested at five locations from 2013 to 2015. Probability curves for *D. barberi* emergence timing were significantly different among hybrid treatments. Most pairwise comparisons for timing of emergence generated significant differences between hybrids; however, pairwise comparisons between the two non-Bt (i.e., with and without Poncho 1250) hybrids, and between the Cry3Bb1 and Cry34/35Ab1 were not significant. Emergence of *D. barberi* beetles occurred earlier in non-Bt hybrids than from Bt hybrids. The probable date for 50% beetle emergence was on Julian day 234 in non-Bt hybrids, and on Julian day 240 in Bt hybrids. Tefluthrin and clothianidin did not significantly influence timing of *D. barberi* emergence. Further research is needed to determine if asynchrony in timing of *D. barberi* emergence between Bt corn and non-Bt corn will impact the extent of mating between Bt-exposed and non-exposed beetles in North Dakota.

P52 Co-inoculation of *Burkholderia ambifara* C628 and *Bacillus simplex* R180 reduced Fusarium root rot disease in corn

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Managing Fusarium root rot in corn using biological control agents (BCAs) is an important component of integrated pest management system for the disease but should be further developed. Biological control has gained more importance given the concern that pathogens are developing resistance against chemical fungicides. Many species in the genera *Burkholderia* and *Bacillus* have been reported as effective plant growth promoting rhizobacteria (PGPR) and BCAs. The present investigation was undertaken to identify strains of *Burkholderia* and *Bacillus* that have broad spectrum effectiveness in controlling various species of *Fusarium*, which cause Fusarium root rot in corn. Many potential BCA strains from our collection, which were recovered from different locations in Nebraska were screened through *in vitro* assay against 7 virulent strains of *Fusarium*. The top 4 *Burkholderia* and 5 *Bacillus* strains were selected and further studied in plants in the greenhouse in a randomized complete block design. *Burkholderia ambifara* C628 and *Bacillus simplex* R180 (GenBank Accession numbers KY515448 and KY515398, respectively) were consistently effective against all *Fusarium* strains tested with percent control ranging from 44 to 76 %. Results from field studies in 2017, involving co-inoculation of these two PGPR strains (C628 and R180) showed significant increase in plant vigor of corn and a reduction in the impact of Fusarium root rot compared to the non-treated control.

P53 Developing a sequential sampling protocol for scouting sugarcane aphid, *Melanaphis sacchari* Zehntner, in sorghum

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Sugarcane aphid (SCA), *Melanaphis sacchari* Zehntner, is a substantial economic pest in grain sorghum in the Southern US. A collaborative project led by Oklahoma State University was tasked with developing an efficient scouting plan for SCA to help producers and consultants determine when the economic threshold has been met. A stratified sampling protocol was developed from data collected in 291 fields from six states (KS, OK, TX, AK, LA, and MS), over two years (2016-2017). The data collected from these sampling events were analyzed using the statistical software SAS 9.4 for within-field spatial population distribution patterns using Taylor's Power Law. The results indicated that SCA populations are highly clumped within the field, and the beta values were used to determine optimal sample sizes over multiple precision levels. A nested analysis of variance (NANOVA) was conducted to evaluate where the most variance occurred within the field. It was determined that nearly 90% (Oklahoma) of the within-field SCA variance could be accounted for within two samplings of three plants in a row, within a 30mX30m cell. Data from

all other states showed that from 52-77% of the within-field variance was accounted for from two samplings of three plants in a row, and when the field-to-field variance was included 72-99% of the within-field distribution variance was accounted for. This information was used to develop a sequential sampling protocol for SCA using a tally threshold based on linear regression models. An efficient sampling protocol enables producers to eliminate unnecessary insecticide applications for SCA management.

P54 Development of a prediction model to improve disease management in sunflower (*Helianthus annuus*)

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Phomopsis stem canker (species of *Diaporthe Phomopsis*) is an important disease affecting sunflower (*Helianthus annuus*) in the United States. In 2017, a model was developed to predict the development of Phomopsis stem canker under natural disease pressure at a total of six locations in Nebraska (1 field), North Dakota (2 fields) and South Dakota (3 fields). To identify weather variables affecting development of Phomopsis stem canker, correlation and regression analyses were conducted using weather parameters obtained from the integrated Pest Information Platform for Extension and Education (iPiPE). Among 11 weather variables, four variables, maximum average air temperature (C), number of days with a relative humidity of at least 70% (X_{RH70}), number of hours with measurable precipitation (X_{Phrs}) and solar radiation average (W/m^2), were correlated to the Phomopsis stem canker disease severity index. One regression model was selected based on higher correlation coefficient and performance in model validation tests. In order to validate the model in the six locations, the risk factors for Phomopsis stem canker was identified based on previous field experiments. A total of 10 treatments were used, which included fungicide applications based on sunflower growth stages and prediction model. At each of the six locations, two sunflower hybrids (a hybrid susceptible and partially-resistant to Phomopsis stem canker) were used. Among the six locations, Phomopsis stem canker disease severity was observed to be the highest in Brookings, South Dakota. However, yield loss due to Phomopsis stem canker was confounded with yield loss due to sunflower rust (*Puccinia helianthi*).

P55 Dispersal of wheat curl mite from virus infected winter wheat

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The wheat curl mite (*Aceria tosichella* Keifer) (WCM) vectors *Wheat streak mosaic virus* (WSMV), *Triticum mosaic virus* (TriMV), and *High Plains wheat mosaic virus* (HPWMoV) to winter wheat (*Triticum aestivum* L.). The complex of viruses causes significant yield loss in winter wheat in the Great Plains. Management during the green bridge period (when volunteer wheat grows after harvest and before the planting of the new crop) is important, and reduces wind-borne dispersal of WCM populations and the associated viruses to the new crop. The objective of this study was to determine the effect of virus infection and symptom development in winter wheat on WCM population dispersal. Flats containing a WSMV resistant variety (Mace) and WSMV susceptible variety (Settler CL) were infested with viruliferous mites of either WSMV or a combination of WSMV and TriMV. The flats were placed in a wind tunnel constructed to mimic WCM dispersal from mite infested wheat. A fan was set up on one end and dispersing WCM were sampled at the other end of the wind tunnel. Mite populations and relative chlorophyll content of plants were monitored through the period of virus symptom development and decline of plant condition. Virus infection and virus resistance in wheat interacted to impact mite population, influencing mite dispersal. More mites dispersed off the plants with higher mite populations. This study provides insight into mite dispersal considerations that are important in making decisions regarding the management of green bridge hosts.

P56 Overwintering potential of *Puccina striiformis* f.sp. *tritici* in North Dakota, USA

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Stripe rust (*Puccina striiformis* f.sp. *tritici*; *Pst*) is an important wheat disease throughout the Great Plains and the world. The pathogen has not been documented to overwinter in North Dakota; however, stripe rust has appeared earlier in the state over the past five years. Given the recent increase of stripe rust reports in the state, the objective of this study was to evaluate the overwintering potential of *Pst*. A stripe rust susceptible hard red winter wheat variety (HRWW) was grown in the greenhouse and inoculated with a local *Pst* isolate. Once pustules were visible, HRWW plants were transplanted at three different locations; conventionally tilled

field, in flax stubble, and a protected elevated garden. As a way to assess an alternative way of survival, leaves with stripe rust were detached from volunteer wheat, placed in mesh bags, and placed at the previously described locations. In monthly intervals, spore viability was assessed from samples collected from transplanted HRWW and detached leaves and compared to a fresh *Pst* spore source. Two replications of each overwintering treatment were assessed at each sampling interval. Urediniospore viability was assessed by measuring germ tube length on water agar and counting number of pustules on inoculated HRWW plants. Results from this research will help understand the biology of *Pst* in the Northern Great Plains and strengthen integrated management strategies.

P57 Detecting sugarcane aphid (*Melanaphis sacchari*) infestation in grain sorghum (*Sorghum bicolor*) using leaf spectral response

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Sugarcane aphids (*Melanaphis sacchari*) are a major agricultural pest to sorghum and infestation can cause up to 70% yield loss without timely insecticide applications (Catchot et al. 2015). Populations can build exponentially on susceptible plants and require frequent field monitoring to determine when densities reach injurious levels. Current monitoring practices for sugarcane aphids (SCA) are time consuming and not practical for high acreage fields. Our overarching goal was to develop more efficient monitoring techniques for SCA using remote sensing technologies but this requires a better understanding of the interactions between aphids and leaf damage. Therefore we studied the effect of SCA density on sorghum spectral responses near the feeding site and quantified potential systemic effects (i.e. plant-induced response). A leaf spectrometer, 350-1044 nm range, was used to measure changes in reflectance by varying levels of SCA density at the site of feeding and distant to the caged infestation. We hypothesized that SCA density can be determined by changes in reflected light and that sorghum plants respond systemically. This research is an important first step in developing more effective pest management strategies for SCA as it showed that sensors can be used to identify an aphid infestation at the leaf level. Future research should address whether such signatures can be observed autonomously using unmanned aircraft systems equipped with comparable sensor technologies. The goal is to improve sampling efficiency and overall decision making for this invasive species and reduce potential yield losses for growers through timely decisions.

•Catchot, Angus et al. "Management Guidelines for Sugarcane Aphids in MS Grain Sorghum 2015." Mississippi Crops: Mississippi State University Extension, 2015.

P58 Risk assessment of *pea seed-borne mosaic virus* (PSbMV) infecting field pea

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Pea seed-borne mosaic virus (PSbMV), a non-persistently aphid-transmitted potyvirus, has been reported in field pea (*Pisum sativum* L.) growing regions worldwide. Susceptibility and yield are influenced by PSbMV, pathotype and host genotype. Isolate ND14-1, recovered from North Dakota infected seed and preliminarily identified as pathotype 4 (P4), was mechanically inoculated onto 20 field pea cultivars under greenhouse conditions. A risk assessment was developed based on cultivar susceptibility, yield reduction, and PSbMV seed transmission. Risk factors were weighted based on importance to the typical commercial field pea producer. Cultivar susceptibility was weighted at 20%, yield reductions at 50%, and seed transmission at 30%. A risk index value (1 to 9) was assigned to each field pea cultivar to represent the risk assumed when the cultivar is grown where PSbMV is present. Cultivars with a risk index value of 6 to 9 were classified as high risk, 3 to 6 intermediate risk and 0 to 3 low risk. Four cultivars were classified as high risk given large yield losses, high frequency of seed transmission, and susceptibility to PSbMV. Twelve cultivars were identified as moderately susceptible due to smaller yield losses or reduced susceptibility to PSbMV. Four cultivars were classified as low risk. Two cultivars were low risk based on a resistance to PSbMV infection whereas two other cultivars were classified as low risk based on PSbMV infection not eliciting a yield loss. These cultivars could be characterized as tolerant given the lack of a yield response to PSbMV infection.

P59 Fungicide treatments and wheat cultivar resistance: Two key strategies to effectively manage Fusarium Head Blight and Deoxynivalenol in southeastern Nebraska

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Fusarium head blight (FHB), caused mainly by *Fusarium graminearum*, is a major threat to wheat production. FHB causes economic losses due to reduction in yield and accumulation of

mycotoxins such as deoxynivalenol (DON) that are harmful to humans and livestock when ingested. The most effective strategy for management of FHB is an integrated approach that combines fungicide application, cultivar resistance, and cultural practices. In the growing seasons of 2015 and 2016, dryland and irrigated field trials were carried out to investigate the effects of fungicide chemical class (triazole versus strobilurin), application timing (anthesis and 6 and 12 days later), and cultivar resistance (moderately resistant versus susceptible) on FHB, DON, *Fusarium*-damaged kernels (FDK), and yield. In both years, FHB, DON, and FDK were significantly higher ($P < 0.05$) and yield was lower in the check compared to the fungicide-treated plots and in the irrigated compared to the dryland trials. A significant effect of cultivar was detected on FHB and DON in both years; however, the effect of cultivar on yield was not significant, except under dryland conditions in 2015. Overall, FHB and DON were significantly lower in Overland than in Overley in both years. Although the strobilurin fungicide reduced FHB, its efficacy was poor compared to the triazole fungicide irrespective of application timing. FHB, FDK and DON reduction by the triazole fungicide was as effective in the anthesis as in the application timed six days later. Results from this research suggest that strobilurin-based fungicides should not be used to control FHB and DON and the window for fungicide application can be widened from anthesis to 6 days later without loss of efficacy. Integration of cultivar resistance with triazole fungicide application at anthesis or 6 days later can be an effective strategy for managing FHB and DON.

P60 Rolled rye for weed suppression in black bean and soybean

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Rolled rye offers the benefits of overwintering cover crops without the requirement of tillage or herbicides for termination. Furthermore, the rye residue on the soil surface can suppress weeds and has potential to control plant diseases. We investigated the weed suppressive potential of cereal rye that was roller-crimped in early June, 2017 at 75% anthesis to soft dough stage. Control plots did not contain cereal rye and were prepared with tillage. Black beans and soybeans were seeded in separate plots and a pre-emergence herbicide (s-metolachlor, 1.9 kg ai ha^{-1}) was applied over the entire field. Weed density and weed biomass were assessed in mid-September. Weed density differed between treatments in black beans ($p<0.001$), with 32.1 weeds m^{-2} in bare soil versus 13.8 weeds m^{-2} in rolled rye. But there was no difference in weed density in soybeans ($p=0.757$), averaging 5.4 weeds m^{-2}. Weed biomass followed a similar trend. The decreased weed density and biomass within the soybean crop likely relates to superior canopy closure. Bare soil plots were composed of 92% and 96% broadleaf weeds in black bean and soybean, respectively. In the rolled rye plots, broadleaf species made up only 46% and 5% of the weed populations in the black bean and soybean, respectively. Results indicated that rolled rye may be used to improve weed suppression in less competitive crops, especially in fields with problematic broadleaf weeds. Subsequent analyses will examine the effects of the rolled rye on yield and disease suppression.

P61 Adapting established IPM strategies to emerging pests: A tale of two stem borers in sugarcane

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The sugarcane borer, *Diatraea saccharalis* F. (Lepidoptera: Crambidae), has been the primary economic pest of Louisiana sugarcane for >100 years. Decades of IPM research have resulted in an effective management program utilizing resistant sugarcane cultivars, conservation biological control, and judiciously timed chemical controls. Recent introduction of another Crambid stem borer, *Eoreuma loftini* Dyar, threatens to destabilize the sugarcane industry. Research findings indicate biological and ecological differences between the two species will require current IPM strategies be adapted to manage the stem borer complex. Predation by red imported fire ants, *Solenopsis invicta*, a key source of mortality of *D. saccharalis*, is not as effective in reducing *E. loftini* injury. Reduced exposure of *E. loftini* larvae relative to *D. saccharalis* will also require revised chemical control practices. Evaluations of cultivar resistance to the two species indicate substantial differences in host preferences exist. Cultivars which impede larval establishment provide resistance to both stem borers, while cultivars exhibiting reduced attractiveness for oviposition vary in response between species. Additionally, dissimilarity in larval feeding behavior requires more labor intensive pest scouting. These differences are further complicated by the occurrence of mixed infestations within the same field. As *E. loftini* continues its eastward expansion in Louisiana, IPM practitioners struggle to adapt control tactics proven effective for *D. saccharalis*. Re-evaluation of widely practiced IPM strategies is needed to prevent widespread economic impacts.

P62 Predators associated with sugarcane aphids and their impact on aphid suppression in sorghum in High Plains

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Sugarcane aphid, *Melanaphis sacchari* (Zehntner) has emerged as the key pest of sorghum in the southern US in 2013. Eruptive population dynamics of this insect in sorghum has also inflicted significant production losses in the High Plains. The

goal of this work was to quantify the diversity and impact of predators of sugarcane aphids on their suppression in the context of commonly implemented management tactics such as insecticide seed treatments, resistant sorghum hybrids, and rescue treatments. In replicated experiments carried out over two years, population dynamics of the aphids, their natural enemies, and relationships among them were examined. It was found that none of the management tactics significantly altered predator abundance. However, diverse and abundant natural enemies of sugarcane aphids were strongly correlated with aphid numbers even after accounting for the effect of insecticide treatments, sorghum variety, or rescue insecticide applications. Furthermore, the highest ratio of predators to aphids was noted in seed-treated resistant hybrids, suggesting that the suppressive effect of these factors on aphid populations may facilitate effective biological control. This research provides support for integrating predators into sugarcane aphid management approaches, especially when combined with host plant resistance and insecticide seed treatments.

P63 Comparing patterns of injury associated with potato leafhopper (Family: Cicadellidae) feeding across different alfalfa (*Medicago sativa*) cropping systems

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Potato leafhopper (*Empoasca fabae*) feeding causes significant damage to alfalfa (*Medicago sativa*), the premier forage crop of North America regarded for its superior yield production and nutritional value for animals. Potato leafhopper feeding on alfalfa induces a wound response, which leads to the characteristic yellowing of leaf tips known as 'hopperburn.' Hopperburn initiates numerous changes in alfalfa, including reduced rates of photosynthesis, transpiration, and internode elongation. Such physiological alterations delay plant maturity, reduce nutritive components, stunt growth, and reduce yields. Different cropping systems, however, offer alternative management practices to control potato leafhoppers. This project aimed to compare three separate alfalfa cropping systems (susceptible cultivar, resistant cultivar, and grass-susceptible cultivar mixture) and four rates of insecticide to formulate integrated pest management (IPM) recommendations for alfalfa growers. The impact of potato leafhopper feeding is well documented on susceptible alfalfa but studies on resistant cultivars or grass-susceptible mixtures are lacking. Therefore, this project compared the effect of different insecticide rates in each system on alfalfa development, yield, and quality, and potato leafhopper damage and abundance.

P64 The status of western bean cutworm, *Striacosta Albicosta* (Smith), in New York State

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In 2009, Western Bean cutworm (WBC), a Lepidopteran pest of corn and dry beans native to North America's Great Plains region and west, was found in NY state. The range of WBC has expanded eastwards and now poses a serious risk to field corn, sweet corn and dry bean growers in NY. In 2010 a monitoring network was established in NY to track the movement of this pest into the state and to alert growers of potential risk. Each year, pheromone traps were placed near field corn, sweet corn and dry bean fields throughout NY and monitored weekly beginning in June. With 100 pheromone traps across the state efficient reporting was important, therefore an app was developed to record weekly counts for each trap. WBC trap catches have steadily increased for eight years. Peak flight occurs between late July and early August. Knowing when peak flight occurs as well as the cumulative trap catch for each site, helps us inform growers when fields are at risk and when to start scouting. An online adult WBC flight model will next be validated for use at newa.cornell.edu, using real time localized weather data from grower owned stations throughout the eastern United States.

P65 *Trichogramma ostriniae* takes on a new challenge: Western bean cutworm, an invasive pest in New York

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Western bean cutworm (WBC), *Striacosta albicosta* (Smith), is an emerging pest of sweet corn, field corn, and dry beans in the Northeast, moving from its historic range in the western Great Plains through the Midwest and reaching New York in 2010. Economic damage was first seen in sweet corn in 2015. WBC larvae infest corn ears, rendering sweet corn unmarketable and reducing yield and quality in field corn. In dry beans, WBC feeds on developing beans. Organic growers of these crops do not have proven methods for controlling WBC. *Trichogramma ostriniae*, a commercially available egg parasitoid used against European corn borer in sweet corn and peppers,

had been shown to parasitize WBC eggs in lab and field cage studies, but had not been tested in open field settings. We released Tost in organic sweet corn, field corn, and dry bean fields at a rate of 90,000 per acre beginning the week after first moth catch and ending the week after peak flight. We documented that *T. ostriniae* parasitized an average of 59% of egg masses and an average of 64% of eggs within an egg mass in sweet corn, but that level of parasitism was not enough to keep the fields below threshold. In field corn, we relied on comparisons of damage levels in release and non-release areas of fields to measure effectiveness. We did not see differences between release and non-release areas. In dry bean fields, damage levels were too low to reliably compare release and non-release areas.

P66 Automated monitoring traps for detection of western bean cutworm (*Striacosta albicosta*)

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Western bean cutworm (*Striacosta albicosta*, Smith) is a growing pest of maize over the past fifteen years. Range expansion to the eastern corn-growing regions, the larvae's gregarious nature, and a resistance to engineered plant traits has made control difficult. Reliable monitoring can make a significant difference and technologies that can be implemented as part of a management program could help these efforts. Spensa Technologies' Z-trap is an automated monitoring device, providing real-time information about a target pest. It has not been tested against *S. albicosta*, so we sought to discover the relationship between the trap's classifier and true counts of the moth. Additionally, we sought insight on: (1) The accuracy of the Hanson simple degree-day model for predicting timing of seasonal population flights, (2) Distribution of nightly moth flights, and (3) Count data for predicting field infestation levels. *S. albicosta* accounted for 73% of all insects collected by the trap. The classifier correlated well with trends in moth flight ($p = 0.68$). Nightly flight data was normally-distributed with peak flight occurring between 12 and 1 am. The simple degree-day model trailed behind the true flight progression by 5-12 days. While there was only a weak, linear relationship between trap events and in-field infestations, fields with significant numbers of infested plants (> 5%) tended to have higher weekly moth counts than fields below threshold values. This information would be helpful in identifying fields to target for human scouting. We discuss the value of automated traps for integrated pest management (IPM) programs.

P67 Improving degree-day models for the flight phenology of western bean cutworm (Lepidoptera: Noctuidae)

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Western bean cutworm, *Striacosta albicosta* (Smith) (Lepidoptera: Noctuidae), is a univoltine pest of corn in North America. Control with foliar insecticides requires timely application before larvae are protected when feeding within the ear. A previous degree-day model for predicting a specified percentage of yearly moth flight used heat unit accumulation above 10°C after 1 May. Because of concerns the previous model was not adequately predicting moth flight, daily data from blacklight moth traps and weather stations at four Nebraska locations (73 location-years) were used to construct degree-day models using simple or sine-wave methods, starting dates between 1 January and 1 May, and lower (-5 to 15°C) and upper (20 to 43.3°C) developmental thresholds. Dates of flight predicted from these models were compared to observed flight with independent location-years to assess model performance with the concordance correlation coefficient to concurrently evaluate precision and accuracy. The best model for predicting timing of *S. albicosta* flight used simple degree-day calculations beginning on 1 March, a 3.3°C (38°F) lower threshold, and a 23.9°C (75°F) upper threshold. The revised flight model indicated field scouting should begin at 1,432 degree-days (2,577 degree-days °F) to estimate moth egg density at the time of 25% flight. This revised model offers growers a more accurate and precise tool to predict when scouting should begin for *S. albicosta* egg masses.

P68 What is going on with the western bean cutworm on maize in Mexico?

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Maize is the base of Mexican food. Western bean cutworm (WBC), *Striacosta albicosta*, is a North American native and emergent maize pest in the USA. However, there are only two reports of WBC as maize pest in Mexico. Maize agriculture is very different in the USA and Mexico. Bt-transgenic maize, pesticide use and other high technology on large areas prevail

in the USA. Maize landraces produced on small areas (i.e. 2 acres) and receiving no pesticides prevails in Mexico, with additional areas producing hybrid seed maize). Because growing transgenic maize is prohibited in Mexico, selective pressures on WBC are very different between these two countries. We detected WBC populations on landrace maize near Huachichil, Coahuila, Mexico and propose a "WBC displacement" hypothesis. Prevailing pests there in early summer (silking-milky ears) are corn earworm (CEW), *Helicoverpa zea*, and fall armyworm (FAW), *Spodoptera frugiperda*, which infest almost 100% of the ears. Both CEW and FAW are aggresive and kill WBC larvae, which are not aggresive. CEW and FAW probably prevent establishment of WBC larvae on ears in summer-early fall. In the fall-winter, CEW and FAW stop reproducing and dissapear from ears: they pupate and diapause (CEW) or die out (FAW). Also, ripe ears are less attractive to CEW moths for oviposition. As CEW and FAW vacate ears, WBC larvae colonize these at low levels (5%) initially, often on very ripe ears. Maize ears are consistently infested (up to 100%) by any of the three worm species, supporting this "WBC displacement" hypothesis. Detailed sampling will clarify the population dynamics and interactions of these pests. It is possible that adoption of *Bt*-transgenic maize in Mexico might favor WBC over CEW and FAW, which are more susceptible to this technology.

P69 Integrated pest management and the role of spiders within Nebraska agroecosystems

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As generalist predators capable of filling a wide variety of ecological niches, spiders play a unique role within the ecosystems they inhabit. A diverse spider community has the potential to intercept and prey upon an array of insect species which could be particularly advantageous within cropping systems. This study sought to reveal the composition and abundance of spider communities within Nebraska agroecosystems under conventional and conservation management and elucidate the trophic relationships between the spider community and key pests of corn. Spiders were collected from four conventional, high-input corn fields and four conservation, low-input corn fields in western Nebraska from May through August 2017. A total of 569 spiders were collected with 242 spiders representing 14 families from the conservation fields and 327 spiders comprising 8 families from the conventional fields. During a preliminary feeding trial, a variety of spider families were starved for five or seven days and then offered one neonate western bean cutworm larva to evaluate predatory response. The majority of spiders tested readily preyed upon the larva. In the second half of this project, the gut contents of spiders will be analyzed to determine whether predation of key pests of corn is occurring, and the trophic interactions of spiders and other arthropods mapped. The results can be utilized to develop improved conservation biocontrol programs in the future.

P70 Screening of entomopathogenic fungi from West Central Nebraska against key pests of corn

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The western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, is the most destructive belowground pest of continuous corn (*Zea mays* L.) in North America. Rootworms are managed primarily via insecticide applications, transgenic hybrids, and crop rotation. However, WCR' s high adaptability to management options motivated this project to look into complementary control tactics. In the U.S., little research has been done to investigate entomopathogenic fungi (EPF) as biological control agents (BCAs) of the WCR. Our goal is to identify key EPF that can be incorporated as BCAs in integrated pest management programs in Nebraska. We surveyed five cornfields to document the complex of EPF species. In the laboratory, we isolated 373 EPF strains from the soil using baiting insects and identified 132 strains with molecular analyses. Pathogenicity assays were conducted with 48 EPF strains to determine if native *Metarhizium spp.* and other species are efficacious against WCR larvae. We determined a range of 0-76% WCR corrected mortality in soil assays and 13.3-36.7% in dipping assays. Ten EPF strains were also tested against another corn pest, the western bean cutworm (WBC), *Striacosta albicosta* Smith. One *Metarhizium robertsii* strain, E1022, was able to cause 54% and 40% mortality on WCR and WBC pre-pupae, respectively. WBC pupate in the soil and thus, any soil inoculation with EPF may also cause mortality of this key pest. Results will be discussed in the context of the potential efficacy of our EPF strains as BCAs for the management of these critical corn pests.

P71 Nebraska growers' and crop consultants' knowledge and implementation of IPM of western bean cutworm

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Western bean cutworm (WBC) (*Striacosta albicosta* Smith) is a native noctuid pest of corn and dry beans in North America. While this pest has expanded its range greatly in recent years, historically it has consistently caused high yield losses in Western Nebraska. A survey was distributed to growers, crop consultants and other agricultural professionals to obtain information about current management practices used for western bean cutworm. Questions covered multiple topics including: demographics, scouting practices, degree day model use, confidence in management knowledge, Bt corn use, insecticide use, and considerations for biological control. There were 95 completed responses received by email. Respondents self-reported significantly higher yield loss due to WBC in 2016 than in 2015 and 2014. Growers demonstrated lower knowledge of WBC identification and management than crop consultants. There were frequent (58.45%) reports of Cry1F Bt corn providing decreased control against WBC. Pyrethroids were the most commonly used class of insecticide (81.04%); among crop consultants, more than half (51.43%) felt that these insecticides were not providing as much control as they used to. This survey identified major concerns for growers and agricultural professionals in Nebraska for western bean cutworm management. An improved understanding of WBC biology and education on management would be most beneficial for growers. Crop consultants would benefit from using more diverse management tactics including: biological control, rotation of insecticide mode-of-action, and diversifying Bt hybrids.

P72 Dispersal and avoidance behavior of western bean cutworm when exposed to *Bt* maize

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Characterization of avoidance behavior to Bt maize, which has been observed in several pest species, is important because it can influence the design of resistance management strategies. *Striacosta albicosta* is an important pest in Canada and the United States, and recently identified in Mexico. This research examines whether *S. albicosta* presents increased dispersal or avoidance of Cry1F and Vip3A Bt maize compared to non-Bt maize using the following experiments: (1) on-plant dispersal: location of neonates assessed after 24h on Bt and non-Bt maize plants; (2) silking behavior: neonates observed for 15 min on Bt and non-Bt maize plants; and (3) feeding behavior: neonates offered Bt and non-Bt maize tissues (leaf and tassel) in choice/no-choice assays. Results indicate that larvae abandoned Vip3A plants 2.1 and 1.7 times more often than non-Bt and Cry1F plants, respectively. Silking behavior was observed 11% of the time on Vip3A, 4.4% on Cry1F, and 0% on non-Bt pla¬nts. Choice feeding behavior indicated a strong preference for tassel tissue. When exposed only to Vip3A, off-tissue behavior represented 38% of the observations; off-tissue behavior accounted for 24% for Cry1F and 28% for non-Bt. Choice experiments indicated preference for non-Bt tassel, and off-plant behavior was more frequent when choice was between Vip3A and non-Bt. Preliminary results suggest that *S. albicosta* might present avoidance to Bt toxins. Further studies in the field are needed to fully understand the potential for larval movement, which can improve resistance management and help delay the development of resistance and/or behavioral adaptation.

P73 Characterizing larval movement of western bean cutworm in field maize

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Western bean cutworm (WBC) is a major maize pest in the US and Canada. Understanding larval dispersal of this species will contribute significantly to IPM and IRM management

strategies. The objective of this study was to evaluate WBC larval movement in the field during three critical movement periods. Moths were allowed to oviposit in removable oviposition cages placed on the tops of maize plants, and the location of resultant larvae was assessed at approximately 2 days (1st period) and 14 days (2nd period) after hatching. Fourth instars were placed on ears and assessed after approximately 19 days (3rd period). Larvae remained preferentially on the infested plants (73.2%) in the 1st period. However, for the 2nd and 3rd periods, more than 77% of larvae were found on other plants. Larval dispersal appears to be non-directional. Further studies are needed in Bt fields; however, preliminary results indicated that refuge-in-a-bag might not be appropriate for WBC due to its high dispersal during the 2nd and 3rd movement periods.

P74 Western bean cutworm feeding damage on Bt hybrids and implications for economic injury levels

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Striacosta albicosta, the western bean cutworm (WBC), is a North American lepidopteran pest of maize that causes economic damage by reducing grain quality and quantity. Late instar larvae damage the ear by consuming kernels on the ear tip or by burrowing into the side of the ear to feed. Current control strategies for WBC include insecticides and *Bt* maize hybrids with Cry1F and Vip3A traits. Although economic injury levels (EIL) and economic thresholds (ET) have been developed for WBC in non-*Bt* maize, such metrics have not been developed for *Bt* maize hybrids despite their use in nearly all maize growing regions and the incomplete control observed for Cry1F proteins. In western Nebraska, 56 plots were planted in 2016 and 2017 with 4 types of maize that provide varying levels of WBC control: non-*Bt*, no control; Cry1A.105+Cry2Ab2, unlikely control; Cry1F, moderate control; and Vip3A, nearly complete control. Natural WBC infestations were adjusted on 25 plants in the center of each plot by removing egg masses or augmenting infestation by restricting live moths on the plants to achieve infestation levels of 0, 8, 16, or 32%. Ten ears were harvested from each plot at maturity and assessed for feeding damage. In 2016, non-*Bt* maize had the highest susceptibility to WBC damage, while maize with Cry1F only performed slightly better than Cry1A.105 + Cry2Ab2. Data from both years will be used to develop EILs and ETs for *Bt* maize hybrids that may help reduce insecticide use and conserve natural enemies in maize fields.

P75 Flight of the western bean cutworm: Population patterns of a noctuid pest over the past 30 years

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Striacosta albicosta (Smith), the western bean cutworm (WBC), is a univoltine noctuid pest of corn and dry beans native to North America. The original distribution of this pest was the west central region of the United States. Since 2000, significant WBC infestations have been documented as far north as Ontario, Canada, east to Massachusetts, and south to Mexico. WBC overwinter as prepupae in the soil and typically emerge as adults in late June to early July. Peak moth flight usually occurs in mid-July in most regions and field scouting for egg masses is recommended between 25-50% cumulative annual moth flight, when oviposition rates are highest. Larvae can cause substantial kernel damage to infested ears. Because larvae located within ears are not exposed to insecticides, applications should occur between oviposition and larval entry into ears. The objective of this study was to characterize WBC flight patterns over 30 years of observations made at black light traps deployed near cornfields in Concord, Clay Center, and North Platte, Nebraska. Trap captures were compared across 5-year periods and sites to test for changes in WBC flight patterns over the course of data collection, and to determine if biological and environmental factors influence annual WBC moth flights. Because efficient scouting is a critical component of a successful integrated pest management program for WBC, understanding changes in flight patterns and seasonal dynamics will improve the timing and efficiency of field scouting and treatment decisions.

P76 Differences in midgut gene expression between *Bt* exposed and unexposed Western bean cutworm

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Control of the Western bean cutworm (WBC) by transgenic corn hybrids that express *Bacillus thuringiensis* (Bt) has diminished over the past decade, such that crop damage is routinely observed in some regions of the United States and Canada. The midgut cellular response of WBC Cry1F resistant larvae was investigated at the transcriptional level by comparison of RNA sequencing (RNA-seq) data between full-sibs either exposed or unexposed to a sub-lethal Cry1F dose via toxin overlay bioassay (10,000 ng cm^{-2}). Out of 52,371 assembled transcripts, 104 and 180 were respectively up- and down-regulated (Log2FC≥2.0 and FDR≤0.001). Among these transcripts, the most highly up- and down-regulated genes respectively encode a glycoside hydrolase and a histone H3-like protein. No differential expression was predicted for transcripts from previously identified candidate Bt resistance genes (e.g. ABC transporters, aminopeptidase N, alkaline phosphatase, or cadherin). This information is important for understanding any variance in cellular response of Cry1Fa toxin resistant WBC larvae.

P77 Landscape-level effects among western bean cutworm developing on Cry1Fa and Vip3A corn in block and blended refuge plants

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Cross-pollination of *Bacillus thuringiensis* (*Bt*) and refuge ears in block or mixed "refuge in a bag/RIB" may influence the effectiveness of refuge plants by providing a variety of kernels in one ear with segregated pyramided toxins of lower doses (Porter, unpublished). If western bean cutworm (WBC) larvae could avoid particular toxins via feeding avoidance of certain kernels than this could potentially serve to circumvent the high dose refuge strategy. The effects of cross-pollination on WBC larval feeding, survival, and development has yet to be fully evaluated in the field comparing block and RIB strategies. Experiments focused only on hybrids with the Cry1F and Vip3A traits and were performed at the Kansas State University. Larger field blocks are needed to avoid cross pollination and these have been chosen over smaller replicated blocks. The block refuge strategy was represented by a 400 ft long by 24 row block of Bt and flanked by a 400 ft long by 24 row block of refuge plants. Mixed refuge strategy was represented by 90 refuge plants being randomly planted within a field 400 ft long by 24 rows wide. Understanding how the survival and growth of WBC larvae is affected by cross-pollinated ears is important. Results address important questions regarding WBC larval survival and selection for increased Cry1Fa tolerance between resistant and susceptible WBC feeding who are exposed to cross-pollinated ears in both RIB and block refuge scenarios.

P78 Survey of bees and syrphid flies associated with flowering soybean in the midwestern United States

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Soybean [*Glycine max* (L.) Merr.] does not require pollination to produce seed. However, soybean produces many flowers that attract insect pollinators. In an effort to determine the community of insect pollinators that visit this crop, we surveyed flowering soybean fields in midwestern states (Indiana, Iowa, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota and Wisconsin) during 2014 (six states) and 2016 (nine states) with a focus on bees (Hymenoptera: Apoidea) and syrphid flies (Diptera: Syrphidae). Two fields per state were sampled. Pollinators were collected using yellow bee bowls placed at intervals along a single transect in each field to determine what pollinator species were present and how far from field edges pollinators would travel. Samples were collected biweekly during flowering, and bees and syrphid flies were identified to species. To date, 1,314 bees have been identified comprising 57 species in 19 genera and 5 families, and 1,190 syrphid flies have been identified comprising 11 species in 6 genera. The most abundant bee genera collected

were *Lasioglossum* (22 spp.) constituting 66.4% of bee specimens; *Agapostemon* (3 spp.) constituting 11.4%; *Melissodes* (7 spp.) constituting 12.8%; and *Halictus* (3 spp.) constituting 4%. Syrphid flies were dominated by *Toxomerus marginatus*, which made up 93.8% of all syrphid specimens. Integrated pest management strategies within soybeans may be important for conserving pollinator species and the ecological services they provide to crops as well as natural habitats.

P79 Economics of *Lygus hesperus* management in Texas High Plains cotton

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Lygus hesperus is an emerging economic insect pest of Texas High Plains cotton. It is capable of causing severe square loss, anther damage, and seed damage depending upon which crop growth stage the infestations occur. It is more pestiferous in the boll development stage than in early squaring stage. The effect of *Lygus* damage to cotton bolls on yield and economic losses and breakeven price was investigated as affected by varying densities of *Lygus* bugs in both choice and no-choice experiments. Individually caged cotton plants or bolls were exposed to five levels of *Lygus* (0, 1, 2, 4 and 6 adults per cage) for one week when plants were at three selected boll development stages (350, 450 and 550 heat units after first flowering, representing an early-, mid- and late-season crop). Lygus-induced lint yield reduction for a given *Lygus* density was lower for late-season compared to that for mid-season infestations, resulting in the significantly lower breakeven price for lint from late-infested crop than that for a mid-season infestation. Because potential yield and economic loss risks due to certain *Lygus* density infestations vary with boll maturation profiles, *Lygus* management thresholds should be optimized to accommodate for temporal fruit maturity dynamics within the crop season.

P80 Evaluation of efficacy of PB ropes in different ecological zones of Punjab, Pakistan

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The pink bollworm, *Pectinophora gossypiella*, have the ability to camouflage themselves within the rosette flowers and bolls, and can reduce yield up to 30%. It is considered to be a critically important pest of cotton all over the world. Field trials in different districts (Vehari, Burewala, Mailsi, Jampur, Rajanpur, Rojhan, and Mianwali) of Punjab during 2017 evaluated the efficacy of synthetic sex pheromone [ZZ/ZE-7,11-Hexadecadiene-1-yl-Acetate] impregnated ropes by using PB Rope L dispensers at 100/acre, at first pin square stage to cause mating disruption. Performance comparison of control fields compared to PB rope treated fields was assessed throughout the year, and in different ecological zones using Analysis of Variance and Tukey multiple comparison means tests indicated a 95% reduction in moth trap catches July to October, in all the tested ecological zones. The mean damage reduction to flowers and bolls was 78 and 62%, respectively during July to October. There were no significant differences in moth catches, rosette flower %, or boll damage % among different Tehsils and cotton varieties. Our studies showed significantly lower damage levels in left over bolls at the time of harvest, and higher overall cotton yield in PB rope plots compared with control plots.

P81 Multi-crop analysis to study the impact of weather parameters on population of beneficial insects in district Sahiwal in Pakistan

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A comprehensive diagnostic survey of Sahiwal District was conducted to estimate the presence of Plant Defense Controllers, better known as beneficial insect fauna, in multi-crop areas using 52.25 inch linear distance (sticks) to measure plant and beneficial insect populations 4 points / acre (multiplied by 1000 gives the total number of plants per acre). Secondary data on weather parameters including rainfall, temperature, and relative humidity were collected from district headquarters of the Pest Warning and Quality Control of Pesticides, Sahiwal. Beneficial count data included mantid, Epicarnia spp., green lace wing, lady bird beetle, Orius bug, pirate bug, syrphids, and others on different crops were studied and prevalence compared using analysis of variance and Tukey multiple comparisons of means posterior tests. Whereas factors intercept and green lace wing numbers are highly significantly different. Green lace wing populations peak at 8 counts at 22°C, followed by a count of 7 at 24°C, 35°C and 37°C. The graphical analysis of relative humidity (RH) and rain fall clarified that only green lace wings are thriving the most humid weather up to 85% RH, it was concluded that green lace wing is the only beneficial insect that survives the maximum and minimum temperature, rainfall, and humidity.

P82 The efficacy of field-collected fungal pathogen against green stinkbug in the Maryland

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Naturally occurring entomopathogens are important regulatory factors in insect populations and they are key components of integrated pest management (IPM) programs. Many species are employed as biological control agents of insect pests in many farming systems. Researchers are continuing to look for the aggressive entomopathogen that could be employed in IPM. In this study, our objectives were to: 1) test the ability of field-collected fungi to kill green stinkbugs, *Chinavia halaris* (Say) (Insecta: Hemiptera: Pentatomidae), a very important pest of soybean in the Delmarva region, and 2) isolate and identify field-collected fungi using molecular techniques. Field-collected entomopathogenic fungal strains were isolated from cadavers of kudzu bug. Based on their colony color they were identified as pink and white strains. The strains were assessed against adult and nymph green stink bugs in the laboratory. Serial conidial concentrations of the pink and white strains were pathogenic to adult and nymph green stinkbugs causing mortality of 75% (pink, nymph), 20% (white, nymph), 35% (pink, adult) and 20% (white, adult), respectively over a period of 3 days. More than 70% of the nymphs treated with pink strains were dead within 3 days of infection. Further tests are underway to identify the pathogen using molecular techniques and to test the effectiveness of the pathogen as a systemic endophyte, thus showing the pathogen is a real candidate as a biological control agent of hemipteran pests and are useful in IPM strategies.

P83 The use of native entomopathogens in integrated management of granary weevil *Sitophilus granarius* (L.) (Coleoptera: Curculionidae)

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The granary weevil, *Sitophilus granarius* (L.) (Coleoptera: Curculionidae), is considered a major insect pest of stored grains worldwide. They can cause large economic damage to stored products. The granary weevil can infest grains, and immature development occurs within the kernels. Secondary damage occurs when insect infestations in stored grain lead to production of excess heat and moisture, these situations promoting fungal growth. Control of stored-grain insects in many countries relies on chemical insecticides and some fumigants. However, the use of unregulated chemical insecticide can cause undesirable side-effects. The aim of this project was to evaluate the use of entomopathogenic microorganisms as an alternative method to control insect pests of stored grains. Commercial formulations of *Bacillus thuringiensis tenebrionis*, *Beauveria bassiana*, and *Metarhizium anisopliae*, as well as native entomopathogenic microorganisms were tested for their efficacy in controlling *S. granarius* on wheat seeds. The native entomopathogens were collected from five different commercial cornfields in Nebraska from soil baiting with *Galleria mellonella* and *Tenebrio molitor* once every three weeks for two summers. The recovered microorganisms were spray-inoculated onto wheat seeds and the seeds were infested with *S. granarius*. By investigating the potential microorganisms, a new approach which is an effective and environmentally friendly way to manage stored grain pest could be obtained.

P84 Adding risk associated with weed management to a decision support system for peanut

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A web-based decision support system (DSS) was created to assist peanut growers in North Carolina with pre-season risk assessment and pest management decision-making. The DSS was created to help growers and their advisors assess the potential impact of competing and/or supportive management strategies on multiple pest species. Individual risk indices were created for five diseases, two arthropods, and three nematodes. Overall risk for the 10 pests and total cost of management are included. Risk of weeds was not included in the original version of the DSS. However, weeds can have a major negative impact on peanut yield if not adequately controlled. Proposed categories for the weed section include: weed species, history of herbicide resistance, irrigation, peanut population, previous crops, history of weed control, number and timing of herbicide applications, cultivation, ability to remove weeds by hand, and diversity of herbicide modes of action.

P85 Extension of information to farmers from research in Ghana designed to mitigate aflatoxin contamination in peanut

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Research supported by the Peanut and Mycotoxin Innovation Lab (PMIL) was conducted from 2012-2016 in two villages in rural Ghana to compare interventions in the field, during drying, and in storage designed to reduce aflatoxin contamination in peanut-based food products. Combinations of improved fertility and pest management, drying on tarps, and storing in sealed bags reduced aflatoxin contamination compared with standard farmer practices. Surveys of "PMIL Collaborating (PMIL-C) farmers, PMIL Spill-over (PMIL-SO) farmers, and General/Other (GO) farmers were conducted in October 2016 to determine how information derived from PMIL interactions was disseminated. Total sample size was 112 (26 PMIL-C farmers, 21 PMIL-SO farmers, and 65 GO farmers). Ninety-six percent of PMIL-C farmers had heard about aflatoxin while only 52% of PMIL-SO farmers and 22% of GO farmers had heard about this issue. Most farmers removed moldy grains (the source of aflatoxin) prior to consuming or marketing peanut. PMIL-C farmers were using improved technologies or recommendations more than PMIL-SO and GO farmers. Approximately 85% of PMIL-C and PMIL-SO farmers used tarps for drying while only 42% of GO farmers used this technique. Hermetically sealed bags were used by 46%, 5%, and 2% of PMIL-C, PMIL-SO, and GO farmers, respectively, while 4%, 9%, and 14% of these respective groups used poly bags. Fifty-two percent of PMIL-C farmers used fertilizer bags while PMIL-SO and GO farmers used this type of storage bag 86% and 79% of the time, respectively.

P86 Parasitism of the invasive brown marmorated stink bug by a native tachinid fly

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The invasive brown marmorated stink bug, [*Halyomorpha halys* (Stal) (Hemiptera: Pentatomidae)], has become a serious agricultural pest in the mid-Atlantic United States since its introduction in 1996. Biological control by native species may play an important role in suppressing *H. halys* populations and lessen reliance on chemical control. While parasitism of *H. halys* eggs has been well documented, there are few examples of parasitism of adults—a life stage that is difficult to control chemically. We collected *H. halys* adults in and around agricultural areas of five Pennsylvania counties over two years to examine the extent and characteristics of parasitism by a native parasitoid, *Trichopoda pennipes* Fab. (Diptera: Tachinidae). Parasitism rates did not differ across years, but did differ among counties ranging from 1.2 to 3.3 percent. Instances of multiple parasitism were evident and eggs we more commonly found on the ventral side of the thorax, although no differences in egg deposition were found between male and female stink bugs. Our results suggest that *T. pennipes* has begun to exploit *H. halys* populations in Pennsylvania. *T. pennipes* is known to regionally specialize on other hemipteran pests, and thus has the potential to play an important role in regulating *H. halys*. Parasitism of *H. halys* by *T. pennipes* should continue to be monitored, and landscape management and IPM practices that conserve *T. pennipes* populations should be supported in agricultural areas where *H. halys* is found.

P87 Estimating the trapping area of the brown marmorated stink bug pheromone

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Halyomorpha halys (Stål), the brown marmorated stink bug, is an invasive, polyphagous insect pest that causes serious economic injury to numerous agricultural crops in the United States. Following the identification of the two-component aggregation pheromone of H. halys, research priorities are focused on refining the protocol for monitoring *H. halys*

populations using pheromone baited traps. As part of this effort, we conducted a series of experiments to quantify the plume reach, trapping radius and trapping area of the *H. halys* pheromone in combination with a pheromone synergist. The study was conducted by releasing marked *H. halys* adults from different distances (10m, 20m, 40m and 60m) at four cardinal directions from the pheromone sources. The number of marked bugs captured within the 2-m radius from the sticky card was counted every 2 hours for 12 hours. Three separate releases were conducted (~1,300 adults released per trial) and all releases were done in an open grassy field to exclude the effects of host plants on the recapture rates. The average recapture rates at 10m, 20m, 40m and 60m distances from the pheromone source were 18%, 8%, 3% and 2%, respectively. Following the published methodology used to estimate the plume reach, trapping radius and trapping area of the codling moth (*Cydia pomonella* L.) pheromone, we estimated that the *H. halys* pheromone with a synergist has a <3 m plume reach, ~121 m trapping area and ~11.93 acres trapping area. This information are critical in developing effective and cost-efficient monitoring programs for *H. halys*.

P88 An IPM answer to grape rootworm—A reemerging vineyard pest

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Grape Rootworm (GRW), *Fidia* species, a beetle in the family Chrysomelidae, has reemerged as a major insect pest of grapes in the Lake Erie region. GRW feeds on the leaves of grape vines as an adult, but does most of its damage to vine roots at its larval stage, which can cause lower vine vigor or even vine death. The traditional recommendation is to scout during the first week of July. However, if first scouting is conducted at this timing it can miss the first portion of the breeding population. This project looks at (1) optimal timing of scouting, (2) development of a GDD model for use in timing scouting, (3) effectiveness of insecticides labeled for this pest, and (4) are entomopathogenic nematodes an effective biological control of GRW? Four growers participated in the study by providing 8 vineyard blocks with a history of GRW with three of those blocks serving as a control. All blocks were scanned once per season using Normalized Difference Vegetation Index (NDVI) sensors to develop canopy maps used in determining the areas to concentrate scouting and as a way to compare the overall area affected by GRW on a year-to-year basis. Through this project, 4 additional modes of action were obtained through FIFRA 2(ee) recommendations to provide growers tools for a resistance management strategy. The *Environmental Impact Quotient*, Kovach, et al. was used to assess the potential impact of insecticide choices on growers, farm workers, consumers, and the environment.

P89 The tale of two nepoviruses in Washington state vineyards

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Nematode-transmitted viruses or nepoviruses cause degeneration/decline symptoms in susceptible wine grape (*Vitis vinifera*) cultivars. During vineyard surveys, *Grapevine fanleaf virus* (GFLV) and *Tobacco ring spot virus* (TRSV) were documented in Washington State, the second largest wine grape-growing region in the United States. TRSV was detected in three red-fruited wine grape cultivars in a single commercial vineyard, whereas GFLV was detected in two red-fruited wine grape cultivars planted in two commercial vineyards located in distinct geographic locations in the State. Symptomatic vines infected with either GFLV or TRSV showed stunted growth, displayed a wide range of foliar symptoms and produced small clusters containing uneven sized berries. No obvious correlation was observed between the type of symptoms in wine grape cultivars and the presence of GFLV or TRSV, suggesting that virus-specific diagnostic assays are necessary for reliable diagnosis of these two distinct viruses in vineyards. The spread of TRSV was demonstrated from symptomatic grapevines to healthy cucumbers used as transmission bait plants. Among the several nematode species found in the vineyard soil, the dagger nematode, *Xiphinema rivesi*, was implicated in the spread of TRSV. In contrast, GFLV was not transmissible from symptomatic grapevines to healthy cucumbers used as transmission bait assays. This could be due to the absence of *X. index*, the known vector of GFLV, even though three other dagger nematode species were present in the vineyard soil. These results are helping to deploy science-based strategies for the management of GFLV and TRSV in commercial vineyards.

P90 Field-level fungicide exposure to honey bees (*Apis mellifera*) during orchard bloom in Michigan

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Fungicides are critical tools for managing diseases in Michigan orchards during bloom. Most fungicides are considered safe for use around honey bees (*Apis mellifera*) based on laboratory toxicological studies on individual bees. New research suggests that fungicides have sub-lethal effects at the colony level through a variety of mechanisms. Some of these sub-lethal

effects include synergism with insecticides and in-hive miticides, decreased immune function, gut microbe interference, and increased larval and colony mortality. Quantifying field-level exposure to fungicides and understanding how honey bees interact with orchard crops during bloom is an important first step in developing best management practices that protect both orchard crops, and the bees that provide pollination. At each of three sites (two orchards and one non-orchard), eight commercial honey bee hives were sampled for nurse bees, foragers, larvae, pollen, bee bread, and wax to determine exposure at different time intervals around tart cherry bloom. Each sample was screened for common early season pesticides: captan, chlorothalonil, thiophanate methyl, chlorpyrifos, pendimethalin and simazine. Pollen was identified using DNA sequencing to identify important floral resources in early spring, and possible sources of exposure. Many of the average pesticide detections are at levels known to cause negative health effects for honey bees based on previous toxicological studies. Possible implications on honey bee health based on the detected residue levels are discussed. These findings can be used by beekeepers to assess whether the payout for renting hives to orchards outweighs potential health risks for their bees under current disease management practices.

P91 Straw mulching enhances productivity of virus-infected passion fruit in Uganda

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Passion fruit production is a priority enterprise for commercial farmers in Uganda. Productivity is, however, limited by viral diseases. Resistant varieties would be the most cost effective management option for farmers although no improved varieties have been released for almost 30 years. This research focused on developing short-medium term strategies to enhance crop productivity. Field trials were conducted in two staggered planting cycles using a randomized complete block design with three replications. Kawanda hybrid passion fruit, the most popular commercial variety, was subjected to four treatments including straw mulch, plastic mulch, weeding, and no weeding for two seasons. Results indicated that mulching performed better than weeding in reducing virus disease incidence and improving yield. Straw mulch significantly reduced virus disease incidence (45%) and had the highest yield per plant, compared to other treatments. Plastic mulch produced the longest passion fruit vines. Aphid counts in the different treatments were not statistically different though they varied significantly over time. Straw mulch has potential as a management strategy and gave the highest returns, compared to other treatments. Its adoption, however, would require further evaluation under intercropping system that most farmers practice with passion fruit. This information will contribute towards the development of an Integrated Pest and Disease Management package for viral diseases and associated aphid vectors in passion fruit.

P92 Right to the core: How Eco Apple® successfully reduced pesticide risk in northeast apple production

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The Red Tomato Eco Apple Project began in 2005 to increase market share of local and regional apples grown using the most advanced ecological farming practices. Even with the careful application of Integrated Pest Management (IPM) principles, pesticide risks are still generated and must be carefully addressed. The program is a collaboration of growers, scientists and marketers who review and update a production protocol and self-assessment annually to include the latest science. Participating growers document their use of IPM and conservation practices in the self-assessment, submit pesticide and monitoring records for review annually, and undergo a site audit every three years. Apples which meet the rigorous protocol are sold under the brand Eco Apple®, marketed by Red Tomato and the growers. With sixteen participating growers and more than 1400 certified acres, the impact of this 12-year project has been evaluated using the online Pesticide Risk Tool (PRT, www.pesticiderisk.org). PRT applies the best available science to identify pesticide options with the fewest potential environmental and health risks, helps users identify mitigation options for products and uses selected, and generates risk estimates that can be used to document progress in reducing risks over time. There are thirteen indices which estimate risk for impacts for on aquatic, avian, small mammal and soil life, beneficials including pollinators, and worker and consumer health and safety. The analyses describe how pesticide risk has been reduced; reflects the elimination of the highest risk pesticides and adoption of advanced IPM strategies; and identifies opportunities to continue reducing pesticide risk.

P93 Improving integrated pest management of leaffooted bug on almond and pistachio in the San Joaquin Valley

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During the fall of 2015 and 2016, and the fall and spring of 2017, we conducted growth chamber experiments in the laboratory evaluating the cold tolerance of adult leaffooted bug, *Leptoglossus zonatus* (Dallas). Results showed that L. zonatus

has a greater tolerance of cold than previously understood. At an exposure period of four hours, a temperature of -6° C was required to kill approximately 50% of the exposed adults. To evaluate population dynamics and validate laboratory cold tolerance experiments, field population of leaffooted bug was monitored in a 1-mile-long hedgerow of unmanaged pomegranates, located in Fresno County, California. Ambient temperature at the studey site was measured with HOBO temperature loggers and reached below freezing on 11 dates for a duration of one to seven hours. No significant difference in the number of adults or nymphs occurred among the dates indicating that cold events did not significantly affect mortality. Moreover, on all sample dates, no detectable mortality was observed during visual inspections of the vegetation around aggregations and of the soil surface near monitored aggregations. The population dynamic study indicated that *L. zonatus* produced a full generation on pomegranate between Sept and late October. As individuals developed to adults, they emigrated from pomegranate to aggregate on more sheltered overwintering plant substrates, such as Italian cypress and Mediterranean palm. Overwintering aggregations dispersed by early March. Implications of these findings for improving integrated pest management of leaffooted bug are discussed.

P94 Susceptibility of peaches, plums and cherries to spotted wing Drosophila in western New York

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Spotted wing Drosophila (SWD) [*Drosophila suzukii* (Matsumura)] was first found in New York State (NYS) in 2011. This vinegar fly has a serrated ovipositor, allowing it to oviposit into ripening fruit. It can infest the fruit of many plants, but most susceptible are raspberry, blackberry, blueberry, and other late-season, soft-flesh fruit—cultivated and wild. Until 2017, stone fruit in NYS had escaped injury because harvests occurred before detectable trap capture or fruit infestation. However, in 2017, early arrival of SWD, cloudy wet weather, and late harvests contributed to significant SWD infestation in tart cherry, which caused processing loads to be rejected and fruit dumped. Peach harvest was commencing at this time. A study was undertaken of 12 peach varieties at a farm in Williamson, NY, where the tart cherry crop had been infested, to determine if any were infested. The grower had a spray program in place for SWD. Each variety was sampled at or close to harvest and sampled fruit checked with salt flotation and in SWD rearing containers. Fruit from four varieties yielded SWD in either salt flotation, rearing, or both. Although infested fruits were found, the number of infested fruits was low, 11 adults reared out of 6 fruits in 120 fruits sampled and 3 eggs found with salt flotation out of 480 fruits sampled. Fruits were firm when harvested and went directly into cold storage before going to fresh markets. The firmness and fuzziness of the fruit are likely deterrents to SWD infestation.

P95 Effect of plant extract *Ruta graveolens* against the date scale, *Parlatoria blanchardi* Targ., at Biskra oasis, Algeria

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The date scale *Parlatoria blanchardi* (Targ.), (Homoptera, Diaspididae), one of the most devastating pests on date palm, has been causing the considerable damage in Biskra oasis. To minimize the side effect of chemical use against date scale, a study was conducted at Oumache, Oasis of Biskra, by applying plant extract of common rue, *Ruta graveolens*. Extracts were sprayed on the first, second and sixth day of the week. Three different extracts were used: seed extract, seed oil extract and dry leaf extract, with three concentrations (0.25, 0.5, 1.0 ml/ml of water). Extracts were tested on different larval stages and adults under laboratory and field conditions, during the autumn and winter period of the year 2015. Results showed that the scale mortality increased with increasing extract concentration, especially on the second and third larval stages. The highest cumulative larval mortality was found 72 hours after oil extract treatment, with 83% larvae mortality under laboratory conditions and 70% mortality in the fields. For the adult, 70% mortality under laboratory conditions and 45% mortality in the fields were found.

P96 Horizontal transfer of reduced-risk pesticides between oriental fruit fly *Bactrocera dorsalis* (Hendal)

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Oriental fruit fly, *Bactrocera dorsalis*, is one of the most important pests in tropical and subtropical area from Asia to Africa. Among hundreds of hosts, it causes economic damage to fruit crops by female laying eggs inside healthy fruits. Conventional management practice in Taiwan relies on the use of organophosphate and carbamate pesticides. There is an increasing need to incorporate reduced-risk pesticides in fruit fly management program due to the environmental and pest resistance concerns. In contrast to the contact poison of organophosphate, many reduced-risk pesticides have strong bioactivity. Male flies regurgitated insecticide-laced methyl eugenol shortly after feeding on the attractant. This

study evaluated 4 reduced-risk pesticides, chlorantraniliprole, acetamiprid, thiamethoxam, spinosad, as an alternative to organophosphate and carbamate for the fruit fly control. At first, insecticide-laced methyl eugenol was fed to male flies to test the efficacy of insecticide toxicity direct horizontal transfer of male and female conspecific. The results showed male secondary mortality from spinosad and thiamethoxam treatments were significantly higher than other treatments in 48 hours, 75%(±15.55) and 70%(±5.77) respectively. Female mortality from spinosad treatment was significantly higher than other treatments with average of 47.5%(±16). Regurigitant from methyl eugenol fed males were collected on filter paper and presented to recipient flies to evaluate the attraction of regurgitant containing acetamiprid, thiamethoxam, spinosad. Results showed there are no statistical difference among those 3 regurgitants and methyl eugenol. The results of this study demonstrated that the toxicity of the 4 insecticides can be transferred by *B. dorsalis* from individual to community-level and are suitable alternatives to organophosphate and carbamate. This study is the first recorded of insecticide horizontal transfer in *B. dorsalis*.

P97 Management of *Tetranychus urticae* on strawberries using UV-C irradiation

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Tetranychus urticae Koch, the two-spotted spider mite, is a highly polyphagous and worldwide pest of many agricultural crops, including fruit, vegetables, and ornamentals. Growers commonly make repeated applications of acaricides or biological control agents to manage *T. urticae*. In previous studies, UV-C technology has been used for disease management in strawberries but with very limited success in control of arthropod pests. Here, we present this novel technology as a management tool for *T. urticae* on strawberry plants. Potted strawberry plants infested with *T. urticae* were exposed to either no management, or nightly, 60 second bouts of UV-C irradiation for four weeks in a Phytotron greenhouse. The mean number of live mites at three strata (high, middle, low) per leaflet was compared between treatments with plant used as a replicate. UV-C irradiation treatments maintained mite populations below the accepted economic threshold of five mites per mid-canopy leaflet compared with 176 mites per mid-canopy leaflet on untreated plants. UV-C irradiated and control strawberry leaflets had 0% and 65% spider mite webbing, respectively. Untreated plants also had significant yellowing in the leaves compared with UV-C treated plants.

P98 Invasive honeysuckle increases populations of the invasive vinegar fly, spotted wing Drosophila

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Spotted wing Drosophila (SWD) is an invasive and highly destructive berry pest that is now distributed throughout North America, South America, and Europe. SWD is highly polyphagous and will utilize many wild hosts in habitats adjacent to crop fields, which may increase SWD damage within the crop. Currently, we have significant knowledge gaps in the behavior, host-use, and movement of SWD. To address this, we evaluated the role of non-crop hosts, particularly the invasive and abundant bush honeysuckle (*Lonicera* spp.), on SWD movement and infestation into adjacent blueberry. In 2016 and 2017, six blueberry farms in west Michigan were selected for the presence of honeysuckle surrounding the crop. At each farm, two honeysuckle bushes and two non-host locations bordering blueberries were monitored for SWD. Two locations in the crop interior were also monitored. In 2017, we used an immunomarking technique on one farm to mark and capture SWD, allowing us to track their movement between the crop and woods bordering the crop. Two types of protein mark were applied in the blueberry and honeysuckle, and flies were trapped 12, 36, and 72 h after application. In both years, the season-long abundance of SWD within honeysuckle was higher compared to elsewhere on the farm. Scouting farms for wild hosts can allow us to better predict SWD problem areas and target control efforts. Moreoever, we can use this information to better understand the spatial and temporal factors that drive local movement of SWD, to help improve IPM programs for this invasive pest.

P99 Seasonal activity of *Drosophila suzukii* Matsumura (Diptera: Drosophilidae), in North Dakota fruits

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Since its initial detection in 2013, the invasive *Drosophila suzukii* has become a significant pest of hobbyists and commercial small fruit producers in North Dakota. The presence of *D. suzukii* has increased economic losses from severe fruit damage as well as management costs. Yellow sticky traps baited with

the sex pheromones (Alpha Scents, Inc.) were used to monitor for populations of *D. suzukii* at two North Dakota State University research sites in 2016 and 2017. Trap transects were placed within plantings of small fruits commonly grown in North Dakota including *Amelanchier* spp., *Aronia* spp., *Lonicera caerulea*, *Prunus cerasus*, *Ribes nigrum*, *Vitis* spp. and in adjacent woodland shelterbelts. Traps were checked weekly. The date, the number of flies captured, and fruit phenology were recorded during each visit. Data compiled from trap catches revealed that the peak density of *D. suzukii* coincided with individual fruit ripening; however, adult flies were present in all fruits prior to and after berry harvest. Future research will determine the role of small fruits and woodland shelterbelts for survival of *D. suzukii* in North Dakota.

P100 Pest management on new cranberry plantings: Horticultural, regulatory, and economic drivers

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To remain viable, cranberry growers must maximize the production on their acreage; this involves periodic renovation and replanting of new vines with costs ranging from $10,000 to $40,000 per acre. In addition to renovation costs, there is a time-lag before a cranberry planting reaches full production (2 to 5 years, depending on variety) and this is a period of reduced income for the grower. Promoting successful and quick colonization of cranberry vines is important to shortening this time lag and is influenced by varietal selection, planting density, site selection, and horticultural management philosophy and implementation. The cost of pesticides can be prohibitive while the crop is not producing income, and implementing IPM to make management decisions based on pest pressures is critical for cranberry vine establishment and can have long-term impact on successive growing seasons. Economic and regulatory forces can also impact IPM choices. Market pressures have led to approximately one-third of US cranberries reaching foreign markets. Maximum residue levels (MRLs) of important pesticides can limit the pest management options that growers can implement to produce high-quality fruit in quantities high enough to keep the farm profitable. Most cranberries in MA are produced in wetlands and as such, state regulations can complicate business decisions made by MA cranberry growers. A recent task force report from a state-sponsored committee offers suggestions (that could be enacted by the legislature) to help growers remain competitive and promote the development of innovative strategies that can manage pests and support the production of high-quality fruit.

P101 Monitoring spotted wing Drosophila through a statewide network in Ohio

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Since the first detection of Spotted Wing Drosophila (SWD) in September, 2011, the OSU Extension IPM program and the Department of Entomology have joined forces to create a statewide monitoring network to understand the distribution of this invasive pest. This network has mostly been run by trained Extension educators who monitor for this pest on a weekly basis at grower farms in their county from June through September, on crops such as raspberry, strawberry, blueberry, grapes, blackberry, and peaches. The key use of traps is to determine the date of the first positive capture on each farm each year so that a control program is initiated at the appropriate time. The date of first catch varied considerably from location to location. Lure and trap combinations also varied over the six years as improvements were made to either the formulation or trap design in an effort to detect adults even earlier in cultivated crops. Results were reported on an OSU vegetable and fruit pest management website (http://u.osu.edu/pestmanagement/) for other growers to view. One key to the network's success is the short time between trap check, identification of any SWD flies in the sample, and then posting those results to the website, so that nearby growers can use this information to swiftly initiate their management plan upon the first detection of this pest. In 2017, the network consisted of 19 counties representing 40 sites.

P102 Testing novel attractants for *Drosophila suzukii*

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The invasive spotted wing drosophila (SWD), *Drosophila suzukii*, was first detected in California in 2008 and infests many high value crops including: blueberry, raspberry, blackberry, cherry, and strawberry. No lure exists that is highly selective for SWD and growers are unable to accurately

predict fruit infestation. Growers thus apply large quantities of chemical insecticides on a calendar basis to control SWD. In this study we first tested different, previously identified, compounds for their SWD attraction. Next, we determined if combining these compounds enhanced the selective attraction of SWD. These previously identified compounds were isolated from fermentation by-products, yeast, and strawberry leaves. We determined that adult male and female antennae can detect each individual compound via electroantennographic (EAG) recordings. Next, we showed that each individual compound is more attractive to SWD adults than water controls. We then combined individual compounds into three different lures (fermentation, yeast, and leaf) and found that only the fermentation lure was attractive under laboratory and field settings during the growing season. Adding the yeast, leaf, and yeast + leaf lures to the fermentation lure decreased adult attraction compared to fermentation lures alone in laboratory and field settings. Our results indicate that although the individual yeast and leaf compounds are attractive in a laboratory setting, when combined together they attract very few adult SWD in the field compared to our fermentation lure. Further, the addition of these yeast and leaf lures to the fermentation lure reduces its attractiveness to flies in both a laboratory and field setting.

P103 Integrated Pest and Pollinator Management: Investigating impacts of different pesticide programs on pollinator communities in commercial orchards

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Integrated Pest and Pollinator Management (IPPM) is an emerging strategy of pollinator-friendly integrated pest management practices in various agricultural crops. Specifically, the IPPM approach takes pollinator health into consideration while formulating and implementing pest management programs in agriculture and other ecosystems. On commercial farms, IPPM is achieved by modifying existing pest management programs, mainly by selecting lower toxicity pesticides, adjusting application timing and favoring non-pesticidal methods while keeping pest populations at acceptable levels. Landscape context and field margin modifications are also important components of dual management of pests and pollinators. IPPM is crucial in orchard production such as apples, where fruit production and farm profits heavily depend on successful pollination as well as control of arthropods and other pests. We assessed reduced-risk and standard conventional pesticide program impacts on the diversity and abundance of pollinators (bees and syrphids) over three years in Pennsylvania. Continuing with the same fruit crop, in another study, we investigated impact of modifying existing pest management program on the population of a key pest while minimizing the risk of pesticide exposure to pollinators during apple bloom. Implementation of reduced risk practices resulted in lower measures of environmental impact, as measured by standardized Environmental Impact Quotient values, and served to sustain the pollinator community relative to the conventional treatment. Significant differences in pollinator communities were found among field sites, suggesting that farm landscape context influences pollinator community assemblages within orchards. Applicability of the IPPM approach in apple production system and other pollinator-dependent fruit crops will be discussed.

P104 Current distribution of the samurai wasp, *Trissolcus japonicus*, in North America

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The invasive brown marmorated stink bug (BMSB), *Halyomorpha halys* Stål (Hemiptera: Pentatomidae), has caused significant damage to fruit, nut and vegetable crops since its establishment in North America. In its native range in northeastern Asia, it is less severe of a pest than in newly invaded regions and its Asian natural enemies are thought to be

important regulators. In contrast, resident stink bug natural enemies in North America fail to adequately suppress BMSB. The egg parasitoid *Trissolcus japonicus* (Ashmead) (Hymenoptera: Scelionidae) is an important natural enemy of BMSB in its native Asian range and has been under study as a candidate biocontrol agent of BMSB in North America and elsewhere. *Trissolcus japonicus* attacks several other pentatomids in Asia, and laboratory host range testing has shown that it can also attack a number of native American stink bugs, although with widely variable success. Additionally, behavioral cues during the process of searching for hosts result in greater host selectivity. Adventive populations of *T. japonicus* of unknown origin were discovered in mid-Atlantic east coast states (beginning in 2014), the west coast (2015), and the northeastern U.S. (2016). These populations are each genetically distinct and are expanding their range in North America, in some cases by deliberate rearing and redistribution within states. Researchers continue to assess the impact of *T. japonicus* on BMSB populations and on non-target species.

P105 Integrating cultural, behavioral, and chemical strategies to improve organic management of spotted wing drosophila

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Spotted wing drosophila (SWD), *Drosophila suzukii* (Diptera: Drosophilidae) was first detected in California in 2008 and since then has emerged as a devastating pest of small and stone fruits throughout the U.S. Losses due to SWD can be as high as 100%. Currently SWD management is achieved primarily through preventative insecticide applications and is particularly challenging for organic producers due to lack of OMRI approved effective materials. Studies were conducted to evaluate behavioral, cultural, and chemical strategies to develop and implement systems-based organic SWD management programs. Results show that SWD adults are active year-round in regions with mild winters such as the southeastern US and that woodlands surrounding berry fields can serve as SWD population reservoirs. In regions with harsh winters, traps containing a mixture of yeast and sugar plus Scentry lure can be used to detect overwintering SWD females in spring before fruit infestation occurs. Cultural strategies such as thinning canopy and using weedmat as mulch can create less hospitable environment for SWD females to survive and oviposit in the fruit. Use of exclusion tunnels significantly reduced fruit infestation and increased marketable yield. In field trials, Entrust was found to be the most effective OMRI listed chemical to control SWD, however, PyGanic, Grandevo and Venerate can be used as rotational products in season-long programs to control SWD. Based on these findings, several resources were created for stakeholders to help them effectively monitor and manage SWD in organic systems. Further information is available at our project website (http://eorganic.info/spottedwingorganic).

P106 not being presented

P107 Integrated pest management of longan in Vietnam

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The longan (*Dimocarpus longan* Lour.) belongs to the family Sapindaceae and is South-East Asian in origin. It is a subtropical fruit, prefers cool, dry winters and warm, wet summers. In 2015, it was grown over an area of 73,007 hectares in Vietnam and is the second most important crop exported after dragon fruit. Arthropod pests including longan gall mites *Aceria (Eriophyes) dimocarpi*, fruit borer *Conopomorpha sinensis*, oriental fruit fly *Bactrocera dorsalis*, stinkbug *Tessaratoma papillosa*, and the diseases powdery mildew and Phytophthora fruit rot cause substantial yield losses. Out of these, witches' broom caused by *A. dimocarpi* is considered an important syndrome of longan that can cause 50 to 86% yield loss. Extensive research has been conducted in the past to identify the causal organism of witches' broom syndrome but none of the studies was conclusive. In 2015, IPM IL collaborated with researchers at SOFRI and found that witches' broom syndrome is caused by the eriophyd mite, *A. dimocarpi*. The IPM IL in collaboration with SOFRI is developing a longan pest management package incorporating control for this mite.

P108 Ukiah High School Cockroach Project: IPM is a community effort

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The Turkestan Cockroach was inundating Ukiah High School. Ukiah Unified School District (UUSD) reached out to the Department of Pesticide Regulation (DPR) to help them find reasonable solutions to mitigate their pest problem. Through school pesticide use reporting data, DPR determined that the school was using increasing amounts of pyrethroids in an attempt to eradicate cockroaches. The pest management approach at Ukiah needed to change in order to reduce pesticide use and appropriately manage cockroaches. DPR, the University of California Cooperative Extension, UUSD, and concerned parents formed an IPM team. The team conducted a detailed site assessment that included a detailed training inspection, an inspection report, an IPM plan, community outreach, and a Train-the-Trainer seminar. UUSD immediately ceased all pyrethriod perimeter applications and started an in-house monitoring program. Changes in pest management practices began simultaneously which included sealing of outdoor hardscapes, installing and repairing door sweeps, replacing all outdoor trash cans, relying on monitoring and baiting, and changing the active pesticide ingredient to an Indoxacarb and the insectide application methodology. Modifications in pest management practices followed by seasonal changes contributed to an immediate decrease in the insect population. An upsurge in Turkestan cockroach populations is expected this summer as cockroach activity resumes; however, continued pest management efforts should contribute to a steady decline in their populations to acceptable threshold levels over the coming active season. Turkestan cockroaches are well established in Ukiah and eradication is not expected.

P109 Site specific management of nuisance geese on school properties: A case study from New York State

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Canada Geese (*Branta canadensis*) frequenting school athletic fields are a growing concern. New York State school districts that completed surveys in 2001 and 2013 reported nearly a doubling in concern over geese as a pest. In 2014, a large New York State high school was cited for "unsanitary conditions" on its athletic fields due to goose fecal droppings. This spurred a statewide series of workshops and presentations to school facilities staff on how to deal with goose issues. Participants indicated they plan to implement managing turf with geese in mind (including planting fescue), implementing a variety of hazing techniques, exclusion along shorelines and retention ponds, and round ups. Since the birds are usually not limited to a single property, effective management often entails a community-wide approach. A demonstration project in the Rochester, NY area was organized to trial hazing techniques on several athletic fields and to initiate the development of collaborations to reduce resident goose numbers. Only hazing techniques that could be implemented by school staff were considered, including a pyrotechnic device, drone, radio-controlled model truck, ATV, air dancer, and rotating reflector. We found that, in addition to efficacy, a technique needs to fit into the desires and workday of the facility staff in order to be adopted. A community effort was organized to reduce goose numbers in the immediate area of the fields cited in 2014. Property owners with breeding geese were identified and contacted with the goal of instituting extensive egg oiling, which commenced in the spring of 2017.

P110 Recognizing excellence in school integrated pest management

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Pest management in schools is a national priority owing to the presence of vulnerable children. Pest issues often result in unnecessary expenses and under-utilization of the full potential and functionality of school indoor and outdoor environments, causing anxiety and stress to children, teachers, staff, and parents. The University of Arizona Community IPM Team conducts the Arizona School Integrated Pest Management (IPM) Program to address these issues. Recognizing the value of school IPM involves a two-fold effort: (1) helping school staff to recognize the benefits of IPM and assisting them in implementing IPM at their campuses, and (2) working with external agencies and the community to recognize the efforts of the school staff. One Arizona school district recently achieved the highest IPM standard. Over a period of 2 years the district staff attended regular educational sessions, modified their pest management practices, and changed the products and tools they used to manage pests. The district earned IPM STAR certification after undergoing a thorough, 37-point evaluation of its pest management program by an independent IPM professional. During the evaluation, the district obtained excellent scores in several key categories, including having a designated IPM coordinator and trained pest management professionals

on staff, providing public access to their IPM policy and pest management information, regular inspections and monitoring, maintaining pest sighting and damage logs, updating a list of approved pesticides and legally compliant pesticide application records, and correct notification of pesticide applications. Low scoring categories included lack of a designated IPM committee to evaluate pest management actions.

PI11 Stop School Pests online integrated pest management training courses for school employees

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Stop School Pests is a training program with free online and in-person courses for school employees to learn how to proactively prevent pests, improve pest management practices and create healthy, safe spaces for students and staff using an Integrated Pest Management (IPM) approach. The training includes nine courses for different school groups so that custodians, maintenance staff, food services personnel, school nurses, facility managers, school administrators, landscape managers and teachers can learn about IPM as it relates specifically to their line of work. Students spend a major part of each day in school – on average more than 30 hours per week. An unhealthy school environment with hazards from pests and pesticides has a profound effect on their health and affects school employees. Mice and cockroaches can cause and trigger asthma attacks and allergies, over-reliance on pesticides can lead to exposure to dangerous chemicals. IPM is a long-term approach to preventing pests utilizing the least-hazardous, most effective, sustainable and cost-effective methods. Stop School Pests trainings were developed in a multi-year, interdisciplinary project with many experts and with the support of the national School IPM Working Group, a group of experts that collaborates across the country to advance best practices in schools to assure children and staff learn and work in healthy, safe places.

PI12 The effect of IPM outreach to schools via webinars

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The US EPA fully supports the implementation of IPM in Schools, as was shown by the very successful popular webinars series over the past three years. The poster will show the breadth of the Center's Outreach to schools through the webinar series which covered most pest and IPM topics from A–V including ants, bed bugs, basics of IPM, through to termites and vectors of human health concern. The Data numerating the thousands of facility managers, school nurses and administrators reached, and the millions of students protected by proxy will also be shown. Efficacy of the outreach along with venue preferences, and measures of requests for IPM information was also measured for the entire three-year series, all clearly portrayed with info-graphics within the poster presentation.

PI13 Engaging school nurses to promote IPM

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The goals of this two-year project are to provide school nurses with tools, training and information to (1) aid in addressing health-related pests, and (2) to promote and support adoption of IPM policies and practices in schools and communities. School nurses are at the frontlines of public health pest issues. They routinely provide care for students suffering from arthropod-caused stings, bites, and rashes. They educate students, staff and families about lice, bedbugs, ticks and other pests. Although many states require schools to adopt IPM policies and procedures, actual implementation requires full support from administrators and school boards. School nurses can help support IPM policies and practices. They are trusted and highly regarded; hence, they are well positioned to serve as a key change agent in their schools and communities. Nurses are trained to be observant and skilled at making evidence-based intervention decisions. However, they generally lack knowledge of integrated pest management. This is a critical gap, given that IPM is highly dependent on understanding pest biology and ecology. Understanding pests is key to effective use of personal protection and/or local-scale property management interventions. We are partnering with national and state nursing associations to survey school nurses to determine what information they need and how best to provide it to them. Training will be provided via webinar and in-person workshops at school nurse conferences. In addition, we are developing outreach materials such as a tick-removal tool, bookmarks and wallet cards to direct nurses to information, resources and training opportunities.

PI14 City-wide invasive formosan termite monitoring project in Jacksonville, Florida

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A city-wide monitoring program for the invasive Formosan termite, *Coptotermes formosanus*, was completed during the summer of 2017 in Jacksonville, FL at the request of the local government. The request came as a result of termites

damaging a local museum, followed by termites being discovered in large parts of the surrounding neighborhood. Upon further inspection, the termites were infesting not only structures, but living trees located on city rights-of-ways and parks. The local government wanted to know how wide spread the termite populations were in Jacksonville and turned to the University of Florida/IFAS and the Jacksonville Formosan Termite Task Force for answers. After consulting with the New Orleans Rodent and Termite Board and Louisiana State University, a monitoring program was developed similar to the one used in the French Quarter. One hundred and thirty monitoring devices were placed throughout the 918 square miles that consist of Duval County. The monitoring stations funded by local companies are glue boards attached to clip boards that hung on light poles. Each week the glue boards were removed and replaced and the termites identified and counted. Each location where termites were found, their numbers and species were mapped. The interactive map can be viewed at https://duval.ifas.ufl.edu/termites.shtml. The project helped determine the extent of the invasive Formosan termite throughout Jacksonville that in 2018 will be guiding decisions for an integrated pest management program for the city-owned trees.

P115 Evaluation and modeling of TickBot: A tick-killing robot

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Southeastern Virginia is a mixing bowl for ticks and tick-borne pathogens with recent invasions sweeping in from both the north and the south. More than 90% of ticks in the Hampton Roads area of Virginia collected (part of a long-term active surveillance project) are lone star ticks (*Amblyomma americanum*), which are an aggressive human-biting tick species. TickBot is a tick-killing robot that lures ticks, using movement and carbon dioxide, to a permethrin treated cloth as it circles a predetermined perimeter. Previous studies have shown TickBot's ability to protect a treated area from lone star tick encounters for approximately 24-hours. In the summer of 2017, TickBot was implemented at the Child Development Center at NASA Langley, Hampton, Virginia. TickBot supplemented other integrated tick management (ITM) methods used at this site including a mulch barrier and frequent mowing. Mathematical models can be used to explore tick population dynamics, quantify risk of tick-borne disease, and identify strategies to reduce that risk. Using the data from our surveillance project, along with the results from TickBot field studies, a mathematical model was developed to explore optimal ITM usage of the TickBot. Results of this model show the relationship between frequency of TickBot application and probability of tick encounter in the treated area.

P116 The Public Tick IPM Working Group enhances tick-borne disease stakeholder collaboration

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The Public Tick IPM Working Group, funded by the North Central IPM Center, focuses on enhancing collaborative opportunities for groups working to reduce tick-borne disease. The goal of the group is to empower the community of tick-borne disease professionals to effectively promote IPM-related activities and reduce the risk of exposure to ticks and the pathogens they carry. The Public Tick IPM Working Group helped organize the 2016 ITM Symposium, created a Tick Pest Alert fact sheet, hosts a listserv and facilitates monthly conference calls to bring together people who work on tick-borne diseases. Monthly conference calls frequently host expert presentations, notes and presentation slides are made publicly available on the working group's website. The working group's membership includes a wide variety of experts, including entomologists, epidemiologists, pest professionals, activists and veterinarians. Group members with different backgrounds provide important networking opportunities, information sharing and critical review of working group priorities to increase the use of integrated tick management. The Public Tick IPM Working Group poster provides a brief history on the group's activities, an overview of integrated tick management resources and working group projects. We invite you to visit our website for more information and links to our created resources and meeting notes. Please contact Frank Laufenberg, Working Group coordinator or Tom Green, Working Group co-chair, with any questions.

P117 New tools in the vector management IPM toolbox

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New tools have recently been developed and approved by the Environmental Protection Agency (EPA) to aid in the war against pests of public health concern.

Mosquitoes: Scientific tools for mosquito control include modifying fine-tuned mosquito genes and infecting mosquitoes with *Wolbachia* bacterium to prevent breeding and transmission of disease.

Rodents: EPA recently regulated an unregulated substance, dry-ice, for effective rodent asphyxiation within their own burrows- a boon for urban Norway Rat control. Electronic pro-active monitoring "rat-cam" is a proven aid in locating rodents for more effective bait and trap placement.

Bed Bugs: A new biopesticide, *Beauveria Bassiana,* has been registered for the control and prevention of bed bugs. This newly developed fungal biopesticide not only controls the bed bugs that venture out and crawl across the thin application, but the bed-bug deadly fungi is brought back to their harborages to infect other bed bugs, controlling that un-seen population. It also has a 3-month residual efficacy, preventing the establishment of newly introduced bed bugs.

PI18 Integrated pest management of mosquitoes: A case study of West Nile virus in California

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We present case studies of three mosquito control districts in California following the rapid expansion of West Nile virus in California. The districts include urban centers and rural areas. This report documents how the districts use all available integrated pest management tools, and how the districts develop and deploy new tools and technologies that improve their ability to minimize the exposure of humans and the environment to mosquitoes and the products used to control them and minimize the cost of the programs. District outreach through printed and electronic media and in-person participation at community events successfully prevents mosquito bites and transmission of disease by raising awareness. Outreach efforts increase dead bird submissions to the dead bird surveillance program that in turn leads to better monitoring of virus activity in bird populations. Districts employ improved sampling strategies, crowdsourcing, and geographic information systems (GIS) to pinpoint areas of West Nile virus risk and target these areas with higher precision. Higher precision leads to the effective reduction of mosquito populations, and reduced costs and reduced environmental and human exposure to pesticides. Districts are actively involved in continued study of new surveillance methods, and the relationship between surveillance data and the risk of human disease—this relationship is used to make decisions about suppression activities such as pesticide applications. Although the current control methods have been shown to have low environmental and human health impacts, public resistance to the use of some products such as pyrethroids and organophosphates necessitates the discovery of new materials for mosquito management. Mosquito resistance to pesticides used to control them is another important reason to discover new management products. The Wolbachia bacterium is one such management tactic that is in the process of being registered in the United States. If demonstrated to be successful, this product could be an important new tool in the fight against mosquitoes and the diseases that they carry. Finally, education about the concept of risk associated with pesticide use and mosquitoes is necessary to insure that the risks and benefits associated with vector control are broadly understood.

PI19 Cost-benefit analysis of total release foggers (TRFs)

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Differences in pest prevalence in homes result in disparities in pesticide use patterns, the efficacy of pest control products, and health risks associated with exposure to pests and pesticides. Total-release foggers (TRFs) are popular over-the-counter insecticidal products commonly used to control cockroaches. However, little is known about the efficacy and health risks associated with these products. Four TRF products were evaluated for their efficacy at controlling German cockroach (*Blattella germanica*) infestations. Total release foggers failed to reduce cockroach population, while the application of gel-baits resulted in significant reductions in cockroach populations (70-93%) within one month following treatment. Resistance of apartment collected cockroaches to pyrethroids, the active ingredients in TRFs, was extensive (59-347x relative to a pyrethroid-susceptible population), while resistance to fipronil, a common active ingredient in insecticidal baits, was considerably lower (6-23x relative to a fipronil-susceptible population). Knock-down resistance (*kdr*), a mechanism of target site insensitivity that confers resistance to pyrethroids, was widespread, with 96% of apartment-collected populations containing at least one allele of the L993F *kdr* mutation. Swabs of kitchen surfaces revealed large quantities of pesticide residues throughout the kitchen, with dermal exposure rates estimated as high as 1.67 mg d^{-1} for cypermethrin and 4.35 mg d^{-1} for piperonyl butoxide. The ineffectiveness of TRFs at reducing pest populations, their similar monetary cost compared to highly effective bait products, and the high human pesticide exposure risks they carry, call into question their utility in the marketplace.

P120 Impacts of promoting Integrated Pest Management (IPM) in home gardens and landscapes through the Vermont Extension Master Gardener Helpline

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The University of Vermont Extension Master Gardener program offers a toll-free state wide "Helpline" staffed with trained Master Gardener volunteers to answer consumers' questions on home gardening and landscape care. The majority of questions are related to insect and disease identification and management. The Helpline runs from April through October and handles over 600 calls per year. The volunteers also answer emails through the Ask an Expert system plus an email platform where gardeners can post questions along with pictures. The email service is gaining in popularity with about 300 photos/questions submitted in 2017. Gardeners also have the option of visiting the Helpline and bringing in samples for the Master Gardener volunteers to assess. According to the 2017 survey of all the clients using the service, 93% indicated the information received helped identify their pest or disease problem; 60% indicated the information they received helped them use IPM to manage their pest or disease and 37% were able to reduce the use of pesticides as a result of the information received.

P121 Integrated pest management programming for community gardeners

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Community gardening continues to be a re-greening strategy utilized by cities with excess available land and declining populations. This strategy has created new opportunities for urban extension personnel at a time when staffing resources continue to decline. Mahoning and Summit Counties, Ohio are home to urban centers with collectively over 150 community gardens. In many cases, gardeners are not familiar with common pests and vegetable diseases and therefore use pest management practices that are non-research based—often circulated via other gardeners or on social media. In order to serve the integrated pest management needs (IPM) of the community gardening population, the Extension Educators in Summit and Mahoning Counties have developed an on-site program utilizing a tool kit and planning protocol to teach IPM that can be used by Extension Educators, Extension program staff, and Master Gardener Volunteers. Workshops are scheduled at various community garden locations in conjunction with the garden leaders and advertised via social media, word-of-mouth, and flyers. The workshops are held in accessible locations and times. The on-site program consists of a number of hand-on activities as well as a diagnostic walk through the garden. Workshops are held at different times during the season to highlight different issues. Evaluation results indicate that this approach is an effective means to transfer IPM strategies and improve management practices.

P122 IPM education and outreach to urban and community audiences in California

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With approximately 87% of California's nearly 40 million people now living in urban areas, reaching residential audiences to address managing pests is a constant challenge. To respond to the ever-growing urban population, in 2007 the University of California Statewide Integrated Pest Management Program (UC IPM) formally established the "Urban and Community IPM" program to focus more resources on educating these groups to help reduce environmental and human health risks caused by pests and pest management practices, especially pesticides. Since then, UC IPM's urban program has increased both academic and core staff devoted to urban pest issues, and has devised innovative methods to help deliver information to end users. Efforts include the development of online training courses, train-the-trainer workshops, expanding publications and educational tools, engaging audiences through social media, and greatly enhancing our home, garden, and landscape web pages.

P123 Urban gardens as a platform for experiential learning: Pollinator conservation, citizen science, and sustainability

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As we enter a new era of sustainability, education must extend beyond the classroom and bridge disciplines; in this case, garden design and pollinator-science. Our urban landscapes can no longer afford to be purely aesthetic. While gardens must still be beautiful, in order for them to be sustainable, they

must also provide at least one valuable ecosystem function. We consider our pollinator-friendly gardens to be the Swiss Army Knife of the urban landscape: How can a garden help promote bees and prepare students and community members to use IPM-tactics to protect these important resources? How can we raise awareness for the need for pollinator gardens and involve community members in hands-on activities that inspire them to plant their own pollinator-friendly gardens? To demonstrate the importance of urban landscape sustainability and especially pollinator habitat and conservation efforts, we developed lessons and educational materials centered on student-installed teaching gardens. Our pollinator-friendly gardens demonstrate not only the importance of sustainability in garden design and maintenance, but also encourage students and the public to interact with these gardens through a Citizen Science program focused on pollinator protection.

P124 An IPM approach for the control of the common bed bug, *Cimex lectularius* L.

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Bed bugs are now considered a pest of "significant public health importance" and an emerging public health problem across the United States by the US Centers for Disease Control and Prevention (CDC) and the US Environmental Protection Agency (EPA). Public concern over the use of conventional pesticides especially in the home and resistance development in the pests, provides the impetus to explore the potential for the use of botanicals and other natural products as alternative products for management of public health pests. Diatomaceous earth (DE) has also found a new life for pest management with more refined and easy to use products. Diatomaceous earth (DE) dusts are especially useful as crack and crevice treatments for bed bugs partly due to their residual effect and owing to their ability to be transferred horizontally by bed bugs. Our results show that mixtures of DE dust and botanicals are significantly more effective than either treatment alone in terms of enhanced toxicity, reduced killing time and the amount of DE dust used against the common bed bug, *Cimex lectularius*. Increased toxicity of mixtures has been correlated with greater damage to the cuticle and subsequent water loss in the insects. We will demonstrate the potential of using a specific DE dust (DX13™) in the management of bed bugs in an IPM plan.

P125 Making the connection: IPM, in-home childcare, and asthma in Chicago's most at risk neighborhoods

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Children's smaller size, developing organ systems, and behaviors such as playing on the ground/floor and putting items in their mouths makes them vulnerable to the health risks of pesticides and creates a significant need to reduce pesticide exposure in places they live, learn, and play. Many children in childcare spend up to 10 hours in and around the facility, making this setting a critical one to address when attempting to reduce exposure to asthma triggers and other toxins. This project focuses on Chicago neighborhoods that cater to primarily low income populations, often with the least time and resources to participate in continuing education, and have some of the highest asthma prevalence rates in the city (estimated from 16% to 28%). To address the triad of negative health impacts on children—pests, pesticides, and asthma—this project engages in-home childcare providers with dynamic and accessible training and technical assistance to increase their IPM knowledge. A secondary goal is to create at least one demonstration asthma friendly in-home childcare site in each of the two target neighborhoods to act as a resource for the childcare community. Midwest Pesticide Action Center (MPAC) will track the number of targeted childcares completing the on-line IPM in Childcares module, the impact of training on the adoption of IPM practices, and establishing an IPM peer-to-peer education network by neighborhood. The ultimate goal is to decrease pest and pesticide exposures in young children to reduce asthma episodes and triggers.

P126 Entireleaf morningglory in paddy field's levee invades soybean fields

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Soybean fields in Japan are experiencing serious weed issues caused by entireleaf morningglory [*Ipomoea hederacea* Jacq. var. *integriuscula* A. Gray] which are suspected to be invading from outside fields and potentially the levees that surround them. There are no previous studies that research the life cycle or the populations of *I. hederacea* in and around these levees. Additional population dynamic studies will help determine if these are the source populations in soybean fields. Research was conducted in levees of a farmer in Ibaraki, in the central region of Japan, in 2016 and 2017. Weeds in these levees were controlled by herbicide (glyphosate potassium salt) or mowing three times a year: June, July and October. In a quadrant study,

all *I. hederacea* plants that emerged were labelled and growth stages recorded every 1-2 weeks. Results of the population study between the two years were compared. In 2016, *I. hederacea* plants emerged from April through November. Plants that emerged in April fruited in middle June. Plants that emerged in late August through late September produced the most seeds (over 2000 seeds/m^2) in middle September and were found to invade fields and produce, on average, 10.3 vines/m^2. In 2017, *I. hederacea* plants emerged from April through October. Plants that emerged in April fruited in late June. Plants that emerged in late August through middle September produced the most seeds (over 600 seeds/m^2) and were found to invade fields and produce, on average, 2.0 vines/m^2. This limited population study indicates that *I. hederacea* can invade fields from their levees. Weed prevention should take place in the levees after August to prevent distribution with adjacent soybean fields. Some methods such as use of herbicide or mulching have an effect on prevention of *Ipomoea* spp. Combination of these methods in field and levee is promising for IPM practice in agricultural land.

P127 An innovative IPM solution for management of the invasive aquatic weed hydrilla

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Hydrilla [*Hydrilla verticillata* (L. f.) Royle] causes serious environmental and economic impacts in aquatic ecosystems. When left unmanaged, hydrilla creates damaging infestations that choke out native plants, clog flood control structures, and impede navigation and recreation. In Florida, millions of dollars are spent annually to control large infestations of hydrilla. During the past 15 years, hydrilla developed resistance to fluridone and endothall, two of the most commonly used herbicides approved for aquatic use. Our IPM system integrates selective insect herbivory by the hydrilla tip miner *Cricotopus lebetis* Sublette (Diptera: Chironomidae) with a disease causing fungal pathogen [*Mycoleptodiscus terrestris* Gerd.) Ostaz.] (Mt), and low concentrations of the herbicide imazamox, an acetolactate synthase (ALS) inhibitor recently registered for aquatic use. Field testing was performed in limnocorrals (1 m diam. x 1 m depth) installed in three ponds at the UF/IFAS Center for Aquatic and Invasive Plants. Over two years, all possible combinations of the three described tactics were tested to determine the most effective combination to develop an IPM plan. Although results varied seasonally, the tip miner and Mt together or in combination with imazamox significantly reduced hydrilla biomass compared to untreated controls. Midge specific tip damage was evident in all treatments inoculated with the midge, which confirmed the insect was compatible with the Mt and herbicide. A significant reduction in turions also was observed in all treatment combinations during the fall season. These findings indicate that a combination of different biological and chemical tactics can be used to effectively manage hydrilla.

P128 Interactivity among fungi, select *Pinus*-associated insects and the Pinewood nematode in Louisiana

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Although forestry is the leading agricultural commodity in Louisiana, the majority of efforts to understand and manage plant diseases are focused on pathogens important in the production of food, feed, fiber, oil, and ornamental crops. As the result of its worldwide damage to a range of native and exotic *Pinus* spp., the pinewood nematode (PWN) *Bursaphelenchus xylophilus* has received more attention than any other forest-related plant parasitic nematode. The nematode was described first by Steiner and Buhrer in 1934 from Pine trees in Bogalusa, LA. From the beginning, there were references to the intimate association of PWN with *Pinus*-associated species of beetles and fungi. The wilting disease caused by PWN is much more severe in Asia and some countries in Europe than it is in America. One of the primary reasons for this difference in disease severity is the species of cerambycid beetle that transmits and transports the nematode. *Monochamus alternatus* is the primary vector of the nematode in Japan, China and Korea; *M. carolinensis* is the primary vector in the United States and *M. galloprovincialis* vectors the nematode in Portugal and other European countries. Research in Louisiana over the past five years has focused on the evaluation of the mechanism(s) that influence the transport and/or transmission of the nematodes by the beetle. Examination and culture of over 200 species of fungi that exist on and in *M. carolinensis* and the bark beetle, *Ips avulsus* suggests that some species of fungi produce anti-helminthic compounds and others produce compounds that negatively affect, directly or indirectly, the health and/or mobility of the beetles.

P129 An integrated management approach to controlling invasive sea lamprey in the Great Lakes

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Sea lampreys (*Petromyzon marinus*) are parasitic fish native to the Atlantic Ocean. When the Welland Canal was constructed to facilitate shipping in the early 1900's, it allowed sea lamprey to bypass Niagara Falls and invade the Great Lakes. Sea

lampreys thrived in the Great Lakes because of the availability of excellent spawning and larval habitat, an abundance of host fish, a lack of predators, and their high reproductive potential. In 1956, the Great Lakes Fishery Commission (Commission) administered a binational, integrated management approach to controlling sea lamprey in the Great Lakes. The primary method to control sea lampreys is the application of lampricides TFM (3-trifluoromethyl-4-nitrophenol) and Bayluscide (2', 5-dichloro-4'-nitrosalicylanilide) to target sea lamprey larvae in their nursery habitat. A combination of barriers and traps is also used to prevent the upstream migration and reproduction of adult sea lampreys. Successful sea lamprey control has reduced sea lamprey populations by over 90% and has allowed for the rehabilitation of a healthy Great Lakes ecosystem, restoring a fishery valued at more than $7 billion annually. Lampricides are extremely effective, however they are expensive and the potential exists for sea lamprey to develop resistance or develop behaviors that render them less susceptible to lampricides. The Commission continues to support research focused on understanding sea lamprey behavior and physiology to exploit weaknesses, diversifying the network of barriers and traps to increase efficiency, and incorporating the use of pheromones and alarm cues during migratory and mating periods to attract sea lamprey into traps.

P130 Weeds as source of inoculum of *Diaporthe gulyae*, the causal agent of Phomopsis stem canker of sunflower

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Phomopsis stem canker of sunflower (*Helianthus annuus* L.) is an economically important disease in the Northern Great Plains of the United States (Minnesota, North Dakota and South Dakota). Three species of *Diaporthe* (syn. *Phomopsis*) are described to cause the disease—*Diaporthe helianthi*, *Diaporthe gulyae* and *Diaporthe stewartii*. Yield loss of 40% have been observed from Phomopsis stem canker in commercial sunflower fields in the Northern Great Plains. Recently, in South Dakota, *D. gulyae* was isolated from two weed species, *Kochia scoparia* (kochia) and *Chenopodium album* (lambsquarters) plants sampled from a commercial field in Hyde County. The two weed species did not show symptoms of Phomopsis stem canker as observed on sunflower, specifically brown colored lesions, pith degradation and lodging. *Diaporthe gulyae* was isolated and confirmed based on morphology and DNA sequence analyses. Greenhouse studies were setup to test the effect of *D. gulyae* isolates from kochia and lambsquarters on a susceptible confection sunflower inbred cv. HA 288. A sunflower *D. gulyae* isolate was used as the control. Inoculations were performed on six-week-old sunflower plants using the stem-wound method. After inoculation, the sunflower plants were subjected to misting for 3 days. At 14 days after inoculation, disease severity was evaluated using a 0 to 5 rating scale. Results from our greenhouse study show that the *D. gulyae* isolates from kochia and lambsquarters were pathogenic to sunflower (rating scale of 4 and 5). The results suggest that the two weed species may serve as an inoculum source for *D. gulyae*.

P131 Understanding the population dynamics of arthropod pollinators and their host preferences at the UMES campus

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An estimated 85% of the world's flowering plants depend on insects for pollination. Pollinator populations are shrinking due to 4Ps' (i.e., Pesticide, Parasite, Pathogen, and Pollution). University of Maryland Eastern Shore (UMES) has developed a Pollinator Habitat Enhancement Plan (PHEP). The main objective of PHEP is to establish a flower-rich habitat within or around the UMES campus to increase the availability of pollen and nectar resources. Along with this main objective, we have designed two specific objectives: (1) To understand the population dynamics of arthropod pollinators and (2) to study host preferences of arthropod pollinators. The experiments were designed in randomized block design with three types of flowers (zinnia flower, sunflower, and mixed flowers) and three replications. The number of visiting pollinators were recorded in each plot and correlated with flower type. Sunflower plants were visited by significantly greater numbers of honey bees, bumble bees, soldier beetles, small bees and a few butterflies. In zinnia flowers, significantly fewer small bees and honey bees were recorded than in sunflower plants, but there was a higher number of butterflies and moths in zinnia flowers than in sunflower plants. The mixed flowers comprise both zinnia and sunflowers plus six other flower species. The population of the pollinator recorded in mixed flowers was two times higher than the population recorded in zinnia and sunflowers. The population dynamics and composition of the pollinator is positively correlated with the maturity of the flowers during the first season of the experiment. The experiment is in progress and will continue for the next two seasons.

P132 Connecticut Integrated Pest Management Program

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The Integrated Pest Management (IPM) Program is a collaboration between UConn Extension and the Department of Plant Science and Landscape Architecture. Since its inception in 1980, the UConn IPM Program has made great strides in developing and implementing sustainable methods for pest control throughout Connecticut. Integrated Pest Management applies multiple tactics in a variety of settings through the selection of appropriate tools and the education of agricultural industry members and Connecticut citizens to provide sustainable, science-based approaches for the management of plant pests. The UConn IPM Program incorporates all possible pest management strategies through knowledgeable decision making, utilizing the most efficient landscape and on-farm resources, and integrating cultural and biological controls. Program objectives include maintaining the economic viability of agricultural and green industry businesses, enhancing and conserving environmental quality and natural resources, and educating participants on the effective use of biological control agents. In the past four years, the IPM Program Team has directly trained 37,665 people in IPM practices. They represent 290 businesses statewide. A total of 2,335 plant pest samples were diagnosed, and management recommendations were provided to IPM Program participants during the past four years. The IPM Program Team includes: Donna Ellis (IPM Program Coordinator, invasive species, curriculum, nursery, and school IPM), Mary Concklin (fruit), Leanne Pundt (greenhouse), Ana Legrand (invasive species, turf, and landscape), Alejandro Chiriboga (nursery; no longer with UConn), Candace Bartholomew (pesticide safety education), Joan Allen (plant diagnostics), Victoria Wallace (school, turf, and landscape), and Jude Boucher (vegetable; retired).

P133 Ecological IPM: Master Gardeners learning sustainable ways to manage insects in landscapes and gardens

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Ecological IPM provides 12 hours of hands-on training to Master Gardeners to increase knowledge and skills to manage pests sustainably. As a result of the training, test scores indicated a threefold increase in overall knowledge of pest management, a doubling in the ability to identify natural enemies, and a quadrupling in the awareness of reduced risk and OMRI listed insecticides used in landscapes. Post-training evaluations revealed that 100% of attendees: were satisfied or highly satisfied with the training, found the information useful or very useful, believed they could implement the knowledge provided, believed their ability to identify insects had increased, believed they were better able to develop IPM plans, believed they were better able to recommend reduced risk and OMRI listed pesticides. 96% believed they were better able to identify beneficial insects, 95% believed they would use alternatives to pesticides, and 100% planned to share information they learned with others. Follow-up surveys 6 months to 3 years post-training revealed that 97% were better able to diagnose problems, 94% were better able to identify pests, 88% were better able to identify beneficial insects, 88% were better able to share their knowledge. Changes in behaviors included the following: 89% increased their inspection of the garden for pests, 74% increased inspections for beneficials, 63% increased their ability to provide research based answers to clientele, and 59% increased their ability to provide alternatives to conventional chemicals. Master Gardeners learned, implemented, and shared sustainable ways to manage insect pests in gardens and landscapes.

P134 Recently established invasive pests on California ficus trees: Identification, impact, and management

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Ficus trees are widely planted in various California landscape settings. These popular non-native species are valued as evergreen trees with versatile uses and relatively few serious pests. Field observations conducted in several metropolitan areas of California have revealed five new to the state exotic insects (*Gynaikothrips uzelii*, *Singhiella simplex*, *Horidiplosis ficifolii*, *Macrohomotoma gladiata*, and *Trioza brevigenae*) that cause considerable damage to Ficus trees. Pest recognition in the field and damage symptoms were illustrated. The impacts of these introduced insects were evaluated, and various management methods were recommended.

PI35 Novel SAR biopesticide LifeGard® bolsters resistance management toolbox

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LifeGard® WG is the first commercial microbial biopesticide that works exclusively by stimulating the plant's innate defenses against pathogen infection. The active ingredient of LifeGard® WG (*Bacillus mycoides* isolate J, or BmJ) is a gram-positive, spore-forming bacterium isolated by Prof. Barry Jacobsen of Montana State University from the phylloplane of asymptomatic sugar beet during a severe outbreak of fungicide-resistant *Cercospora beticola* leaf spot. While LifeGard® WG works well as a stand-alone in certain crop/disease combinations; it has the greatest value when positioned to supplement disease management programs for fungicide resistance management in mixtures or rotations with conventional fungicides and bactericides. The Fungicide Resistance Action Committee (FRAC) recently placed LifeGard® WG in a new mode-of-action group, P06 - Microbial Inducers of Plant Resistance, providing growers with additional flexibility for resistance management. When applied as a preventative measure before disease onset, then included in one or more subsequent applications, LifeGard® WG has been shown to maintain high levels of disease control with fewer fungicide sprays. This effect is especially pronounced when used on crop varieties already possessing some level of disease resistance. Here, we highlight recent field trial data demonstrating efficacy of LifeGard® WG both alone and within a program against fire blight (*Erwinia amylovora* Burrill), onion downy mildew (*Pernospora destructor* Berkeley), and grape downy mildew (*Plasmopara viticola* Berkeley & Curtis). In each trial, LifeGard® WG replaced nearly half of the conventional fungicide or bactericide applications within a program while maintaining similar levels of disease control compared to the full conventional program.

PI36 Feed 'em and weep? Fertilizer effects on aphid population growth and biocontrol in greenhouse crops

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The effect of several types and rates of fertilizers (water soluble (WSF), controlled release (CRF), and organic granular (OF)) was evaluated on the population growth of both green peach aphid (GPA) and foxglove aphid (FGA) on pepper and pansy in greenhouses. Three adult female GPA or FGA were added to each plant, and two weeks later the resulting aphids were counted. Plant size, dry weight, and percent tissue nitrogen were also recorded. The growth response in peppers was markedly stronger than in pansies for all fertilizer treatments and WSF at either rate produced much larger plants than other fertilizers. In all treatments, the population growth of GPA was much greater than that of FGA. WSF at both rates produced the highest population growth of both aphids. Notably, for pansy, more fertilizer did not result in more aphids, whereas both aphid species increased with increased fertilizer on pepper. Two fertilizer treatments, WSF at 75ppm and CRF at 1.0 kg/m3, were selected to evaluate effects of fertilizer treatment on aphid biocontrol by *Aphidoletes aphidimyza*, *Aphidius colemani*, or *A. ervi* in greenhouses. Three adult aphids were placed on plants and allowed to reproduce for a week. Two newly-emerged females of *A. colemani*/*A. ervi* or *A. aphidimyza* were released. Ten days later the numbers of all aphids, aphid mummies, or *A. aphidimyza* larvae per plant were counted. No significant fertilizer effects were observed for any natural enemy against any aphid on any plant host, at the fertilizer rates and release rates used.

PI37 Control of *Phytophthora* root rot disease of hydrangea using biorational products and fungicides

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Phytophthora root rot, caused by *Phytophthora nicotianae*, can result significant losses in field and container production of hydrangeas. The efficacy of biorational products and fungicides against *Phytophthora* root rot of hydrangeas was assessed in field experiment at the Otis L. Floyd Nursery Research Center in McMinnville, TN. Four replications per treatment were arranged in a randomized complete block design. Plots were artificially inoculated with *P. nicotianae* grown on rice grains. Non-inoculated plots served as control. Treatments were RootShield *PLUS*, MBI110, IT-1503, OxiPhos and TerraClean 5.0+TerraGrow program, Segovis, Empress Intrinsic, and Subdue Maxx. TerraClean 5.0 was drenched into the soil 24 hr prior to transplanting in dedicated plots. TerraGrow at 1oz/10 gal rate was prepared and dedicated rooted cuttings for this treatment were dipped into mixed solution prior to planting and those plants after transplanting received TerraGrow at 0.4 oz/10 gal as drench application. The other treatments were applied as a drench starting after transplanting. All of the treatments significantly reduced Phytophthora root rot severity compared to non-treated inoculated control. The treatments most effective in reducing Phytophthora root rot severity were Segovis, Empress Intrinsic, Subdue Maxx and MBI110. All of the treatments except RootShield *PLUS*+ WP significantly increased the plant fresh weight and root weight compared

to non-treated, inoculated control. Segovis, TerraClean 5.0+TerraGrow and Empress Intrinsic treatments numerically increased plant fresh weight and root weight compared to MBI110, OxiPhos and Subdue Maxx. TerraClean 5.0+TerraGrow and Segovis numerically increased the plant height compared to other treatments and non-treated inoculated control.

P138 Management of Cercospora leaf spot of hydrangea using biorational products and fungicides

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Cercospora leaf spot (*Cercospora hydrangea*) is a destructive leaf disease of hydrangea in the landscape and nursery production. The efficacy of biorational products and fungicides against Cercospora leaf spot of hydrangea ((*Hydrangea macrophylla*) 'Zaunkoenig' x 'Princess Juliana') was assessed at the Otis L. Floyd Nursery Research Center in McMinnville, TN. Four single-plant replications per treatment were arranged in a randomized complete block design outdoor under 56% shade. Treatments were Orkestra Intrinsic, Mural, Strike plus, ZeroTol, GreenClean Pro, Regalia, Mildew Cure and Triact. Severity of Cercospora leaf spot resulting from natural infections and phytotoxicity were determined during the experiment and expressed as the percentage of foliage area affected. All of the treatments significantly reduced Cercospora leaf spot severity and area under the disease progress curve (AUDPC) throughout the experiment compared to the non-treated control. The treatments that most effectively reduced Cercospora leaf spot severity and the progression of disease were Orkestra Intrinsic, Regalia, Mural, GreenClean Pro and Mildew Cure. Phytotoxicity was observed as necrotic flecks and streaks on foliage of plants treated with GreenClean Pro. Non-treated control, GreenClean Pro and Triact-treated plants were not commercially acceptable due to disease severity or phytotoxicity at the end of the experiment.

P139 Augmentative biological control of twospotted spider mite on hops in the midwest

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The twospotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae), is a key pest on hops grown in the Midwestern USA. Hop production is a new industry in the Midwest and therefore little research has been done on mite management in this region. During 2016, trials were conducted to determine the efficacy of augmentative biological control. *T. urticae* populations were monitored on the cultivar 'Cascade' at four hop yards in Ohio. Treatments of *Neoseiulus fallacis* (Acari: Phytoseiidae) and *Galendromus occidentalis* (Acari: Phytoseiidae), each at a high and a low rate, were compared in eight replicates. Mite populations were monitored on leaves at a height of one meter above ground and one meter from the top of plant. When populations reached a threshold of one *T. urticae* per ten leaves, predatory mites were released. Hop yields did not differ significantly among treatments. During 2017, a similar study was done using earlier and more intense sampling, to ensure early detection of spider mites in a system where mite density varied widely. Treatments compared *N. fallacis* released at both a high and a low rate in 17 replicates. Although yields of each treatment did not differ significantly, concurrent cage studies showed that *N. fallacis* did provide adequate control of spider mites when released at a rate of two predators per ten spider mites. Cage studies showed that naturally occurring predators, which include *N. fallacis*, provided some control of *T. urticae*, thus future studies might concentrate on a more economical option such as conservation biological control.

P140 Creating a buzz for IPM in turf care using innovative community engagement

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Many people don't realize that: (1) urban homeowners apply up to 10 times more chemical pesticides to lawns per acre than farmers use on crops; (2) lawn care pesticides are the pesticides most often detected in urban watersheds; and (3) polluted runoff from lawns flow into storm water drains which bypass water treatment facilities and empty out directly into rivers, lakes, and streams. In addition, climate change is likely to magnify these negative impacts in the Midwest, with longer growing seasons pointing to the use of more landscaping products and increasing storminess resulting in more flooding and storm runoff emptying directly into waterways. To combat this issue Midwest Pesticide Action Center developed the Midwest Grows Green (MGG) initiative, a replicable three-pronged campaign to achieve local, regional, and national pesticide reduction. By design, MGG's three-pronged approach allows for cross-promoting the MGG message throughout strategically targeted communities. The campaign uses an easily recognized external-facing brand and message associated with environmentally friendly, sustainable lawn and landscaping practices. Each of the three components works to reinforce the other, thereby providing amplitude to the MGG natural lawn care message. In this way, the campaign aims to transform information-knowledge (general information about natural lawn care and steps to take to achieve it) into action-knowledge (purchasing products, services, and implementing processes) that actually reduce health and environmental impacts.

P141 Partnering with industry to deliver IPM continuing education to Florida's turfgrass professionals

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Turfgrass management professionals in Florida are required to earn approved continuing education units (CEUs) to keep licenses and certifications current, such as state pesticide licenses, Certified Crop Advisor, and Florida Nursery Growers and Landscape Association. This audience has traditionally attended live face-to-face programs offered by the University of Florida and commodity and trade associations. Resource challenges have increased the need for more efficient means of educational program delivery to these audiences. Faced with these challenges, extension educators have become more creative for efficient information delivery mechanisms to save miles traveled, time, and costs. Forming partnerships with private industry can empower extension professionals to differently strategize methods of program delivery and effectively and efficiently reach broader audiences. Since 1953, the Florida Turfgrass Association (FTGA) has been an advocate for promoting the turfgrass industry with support for extensive research, continuing education, and opportunities for turfgrass professionals to network with their colleagues. The major objective of our work was to provide an educational opportunity by offering CEUs to those who work in the turfgrass industry as well as those employed by other agricultural sectors. Our latest single-day distance educational event reached more than 400 professionals at 22 sites using Mediasite® technology delivery.

P142 Detection of *Pythium* spp. in golf course irrigation systems

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Creeping bentgrass is commonly used on golf course putting greens in the U.S. Many pathogenic *Pythium* spp. cause diseases, such as Pythium root rot and Pythium root dysfunction, on creeping bentgrass. Treating these diseases requires multiple fungicide applications, which may not be completely effective due to differing *Pythium* spp. tolerance or fungicide resistant populations. Identifying and targeting *Pythium* dissemination pathways for treatment may be a more cost effective management practice. Irrigation water is a source of *Pythium* inoculum in greenhouses, but golf course irrigation systems have not been screened. Samples of water (2 L) were collected from irrigation heads surrounding two putting greens by placing multiple sterilized containers at random locations prior to irrigation. Zoospores were baited from samples with creeping bentgrass leaves. Subsequently colonized leaves were transferred to *Pythium*-selective media to facilitate mycelial growth. Concentrations of viable propagules are quantified by filtering 500 ml aliquots through membranes (5µm pore size), transferring membranes onto culture medium, and monitoring colony-forming units. The ITS region of DNA extracts from isolates or filter pieces were amplified with oomycete specific primers and sequenced. Two putative *Pythium* isolates were isolated from golf courses near Kansas City, MO through baiting. ITS sequences were compared with Genbank accessions using the BLAST algorithm, revealing a 99% match with *Pythium adhaerens* (AY598619.2) and a 95% match with *Pythium monospermum* (AY598621.1). If irrigation is infested with pathogenic *Pythium* spp., managers may change their irrigation source or treat irrigation water as an alternative disease management tool.

P143 Incorporating organic amendments to enhance control of dollar spot on bentgrass fairways

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Dollar spot (*Sclerotinia homoeocarpa* F.T. Bennett) is a common and widespread disease of turfgrass. While synthetic fungicides are the primary control method, there is increasing interest in alternative controls, including the use of organic amendments. A 2-yr trial was initiated in late 2016 on creeping bentgrass (*Agrostis stolonifera* L.) maintained as a golf course fairway to evaluate popular compost sources for dollar spot control when combined with fungicides. Main plots consisted of a municipal waste compost (Orgro) and a biochar (Mirimichi Green) applied at establishment and as a topdressing applied bi-annually, a vermicompost (Vermaplex) + fertility treatment, and a standard fertility treatment. Sub-plots consisted of fungicide factor (contact 14 d, contact threshold, penetrant 14 d, penetrant threshold, and none). Fertility levels within all main plots were normalized over the trial period. In the first year of the study, we observed a significant reduction in dollar spot incidence for all fertility treatments compared to the non-treated check on 3 of 6 individual rating dates and when comparing area under disease progress curves. Preliminary results indicate that disease development appeared to be influenced by nitrogen content and release of the respective composts treatments. An ongoing analysis of soil nutrients, foliar nitrogen and microbial diversity will aid our understanding of nutrient availability and dollar spot development, as well as enhance our understanding of the non-nutritional effects to consider when incorporating organic treatments.

P144 Fungal communities infecting creeping bentgrass continuously change during the first six months

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Proper use of both synthetic pesticides and biological controls are core components in integrated pest management. In turfgrass systems biological-based products are often considered unreliable as reports show inconsistent control, even within a single location. Since many biological products are microbial-based, it may be possible to optimize their efficacy through understanding the resident community of plant-associated microorganisms. These existing plant-associated microbial communities are a possible hurdle to the successful establishment of applied biologicals. Creeping bentgrass (*Agrostis stolonifera* L.), the most widely-used turfgrass species in golf course settings, was seeded in conetainers (85% sand and 15% peat; standard US Golf Assoc. rootzone mix). Seeded conetainers were maintained in a greenhouse, and samples of foliage and roots were taken at emergence and every two months thereafter, separating at the chlorophyll line. PCR amplicons were generated from sample DNA using fungal ITS3 and ITS4 primers. Amplicons representing the complete fungal community were used to construct next-generation sequencing libraries for processing on an Illumina MiSeq. DNA sequences were analyzed using DADA2 1.6, QIIME2 and phyloseq programs, yielding 1,116 unique amplicon sequence variants. Significant differences in microbial diversity (Shannon and beta indices) were observed over the six-month period ($p < 0.05$). These findings show that the fungal community is constantly changing as the plant grows from seed to maturity, and that even after six-months, has not reached a climax state. Therefore, biological controls may need to be introduced later than six-months, but possibly before a full climax community is reached, to maximize their efficacy.

P145 Use of unmanned drones in Maryland nurseries as part of our IPM outreach

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Several Maryland nursery operations have expressed interest in investigating use of drones for use in diagnostic disease and insect IPM, and water-nutrient monitoring. They have also expressed interest in investigating use of drones to inventory plant material in a field production nursery environment. The University team of investigators realize that the use of drones and infrared cameras to monitor for disease, insect, water-stress and nutrient problems will involve a long term investigation. Toward this end we will investigate funding for this long term research project. For the short-term research efforts we investigated the use of drones to inventory plant material in a working field nursery and low-cost infrared cameras attached to smart phones for identifying plant stress. Funding from the Maryland Nursery Landscape and Greenhouse Association (MNLGA) was used to support a part-time technical student from the UAS drone program to work on refining existing software packages paired with drones to inventory plant material.

P146 Field trials to evaluate low risk pesticides for Japanese Beetles, *Popillia Japonica*, in nurseries

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Japanese beetle populations reached heightened levels in 2015 and 2016 after three wet summers in a row. The high soil moisture levels , during egg laying time for Japanese beetles, in 2013, 2014, 2015 and 2016 increased the survival of larval stages of the Japanese beetles. The adult Japanese beetles are inflicting major damage on several species of nursery plants. As part of our IPM effort we have been trying to encourage nursery managers to use low risk pesticides to control pests and reduce the collateral damage to beneficial organisms. Our field research efforts are geared toward testing out new materials for potential control of pests in nurseries. The beetleGONE! (BTg) from Phyllom BioProducts Corp., Mainspring and Acelepyrn from Syngenta Company fit well in our IPM efforts. In year one we evaluated foliar applications. In year two, we compared foliar applications to soil applications made in fall and spring. Our work will help quantify whether these material are effective in controlling Japanese beetle adults in working nurseries. In year two we did not include BTg since the manufacturing company was having problems in production of the product and did not supply material for the second year of the project.

PI47 New resources on thrips IPM in greenhouse production

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Use of biological control in greenhouses by vegetable and ornamental growers has increased substantially over the last 10-15 years in Ontario, Canada. All vegetable growers surveyed are now using biocontrol, whereas in 2001 over 90 per cent of tomato and pepper growers and only 50 per cent of cucumber growers used this strategy. Biocontrol use among ornamental growers has more than doubled in the same period, increasing from 26 per cent to 69 per cent. Thrips remain the driving force behind biocontrol use, particularly for ornamental growers. This pest is a pervasive threat and growers have to take proactive steps to prevent populations reaching damaging levels. With resistance a constant issue, and increased incidence in new crops, research to define more effective use practices for biocontrol agents and integrate them into crop management systems is crucial to allow growers to keep pace with this ever-evolving pest. This poster presents a variety of resources developed to communicate research results and recommendations to the industry, including the website www.greenhouseIPM.com, a 6-part article series published in the Greenhouse Canada magazine and several short videos demonstrating IPM techniques or principles.

PI48 Optimizing irrigation management can reduce pesticide loss in nursery production

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Ornamental plant production is reliant upon herbicides and pesticides to produce a salable crop. Once applied, these compounds are subject to a variety of fates outside of their intended purpose. Pesticides can be exported with runoff or leachate from production facilities, with concentrations dependent upon the specific properties of the compound as well as how irrigation is being managed. In a study conducted on the Michigan State University (MSU) Horticulture Farm experimental nursery, ten pesticides common to the nursery industry were applied to distinct production zones under three different irrigation treatments. Total quantity of runoff and leachate was measured for each production zone and analyzed for pesticide concentration to determine agrichemical load. Pesticide applications were split into three events throughout the growing season, and samples were taken at pre-determined intervals following application. Throughout the course of this study, conventional irrigation practices resulted in the highest amount of water export—carrying with it elevated levels of certain pesticides. Excessive irrigation can not only transport pesticides downstream but can also mitigate its intended effects in production. By optimizing irrigation management, growers may be able to reduce the risk of pesticide loss to the environment without sacrificing production quality.

PI49 Developing and implementing effective integrated pest management strategies for specialty crop growers in north Florida

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Florida A&M University's (FAMU) Extension Integrated Pest Management (IPM) Program on specialty crops has been developing and implementing effective IPM strategies for small farm growers since 2010. The target strategies include regular monitoring for pest problems, identifying pests and beneficial species, and their life stages, keeping good records of pests, use of proven best management practices, use of plant-mediated pest management, practicing good sanitation, conservation of biological controls agents, and application of minimum use of selective pesticides. FAMU's extension IPM program applies current, comprehensive information on the life cycles of pests and their interaction with the environment. The IPM approaches we are developing and evaluating can be applied to both agricultural and non-agricultural settings, such as the homes, community gardens, and workplace. In addition, undergraduate and graduate students and extension agents are obtaining training on crop production and protection practices in specialty crops. IPM takes advantage of all appropriate pest management options including, but not limited to, the judicious use of pesticides. For example to manage Southern Green Stink Bug, *Nezara viridula* (Hemiptera: Pentatomidae) in tomatoes, use of trap crops (sorghum, sunflower and millet) and refuge crops (three varieties of sweet alyssum) were evaluated using 'push' and 'pull' strategy to manage this pest effectively. In case of small fruits (blueberries and blackberries) crop protection, we evaluated several traps and bait systems

to properly monitor and manage the spotted-wing Drosophila, *Drosophila suzukii* (Diptera: Drosophilidae). Other pests are being monitored and managed using effective IPM strategies to sustain crop productivity and profitability.

P150 Use of multiple natural enemies to manage whiteflies on poinsettias

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Poinsettias *[Euphorbia pulcherrima* (Willd. ex Klotzsch)] were valued at $140M in 2015, comprising approximately 1/6th of the total value of potted flowering plants in the US. The main pest of poinsettias are whiteflies, with *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) as the most common species occurring in southern USA greenhouses. The increasing prevalence of the Q-biotype whitefly, increasing instances of pesticide resistance, increasing restrictions imposed by the EPA on pesticide applicators, and increasing requirements from retailers are calling into question the long-term use of insecticides to manage *B. tabaci.* Two natural enemies demonstrate promise for use in management of *B. tabaci* in the warmer climates of southern USA; *Eretmocerus eremicus* Rose (Hymenoptera: Aphelinidae) and *Amblyseius swirskii* Athias-Henriot (Acari: Pytoseiidae). *Eretmocerus eremicus* can disperse over 10 meters in field conditions and find patches of whiteflies in the greenhouse. In contrast, *A. swirskii* is relatively immobile, but can persist on plants for four weeks or longer, providing a sustainable baseline approach to manage new whitefly populations. In this study, we investigate which natural enemy composition would best suppress *B. tabaci* populations in large cages (each with 12 potted poinsettias) at release rates economically comparable to current conventional insecticide inputs: *E. eremicus*, *A. swirskii*, or combination of *E. eremicus* and *A. swirskii.* The results provide insight into the use of multiple natural enemies to suppress pests in greenhouse crop production.

P151 Population dynamics and control of the crapemyrtle bark scale

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The crapemyrtle bark scale (CMBS), *Acanthococcus lagerstroemiae* Kuwana (Hemiptera: Eriococcidae), is an exotic pest of crapemyrtles, *Lagerstroemia* spp., first reported in the US north of Dallas (Texas) in 2004. The scale has since spread across 11 states in southern USA. Crapemyrtle bark scale feed primarily on the bark of crapemyrtles, resulting in honeydew deposits followed by the presence of sooty mold. Crapemyrtle bark scale has been reported on 17 plant genera in 13 families in its native range and has been found on *Callicarpa* sp. (beautyberry) in East Texas landscapes. The newly emerged hatchling scale insects, referred to as crawlers, were monitored on five branches on each of three trees across multiple locations in Texas (4) and Louisiana (2) from 2015–2017 to determine timing of peak crawler activity. Crawlers appeared to increase towards a peak in activity between the beginning of April and beginning of May, providing a one-month window of exposed crawlers. Second and third distinct peaks could be observed later in the season, suggesting non-overlapping generations of crapemyrtle bark scale. A combination of landscape and potted crapemyrtle insecticide efficacy trials were conducted from 2016–2017. Dinotefuran and imidacloprid demonstrated excellent efficacy as soil drenches using the label rate and bifenthrin, pyriproxyfen, buprofezin, and dinotefuran were highly effective at managing crawlers as bark sprays. Natural enemies have demonstrated 75% suppression of crapemyrtle bark scale populations in the landscape.

P152 Control effects based on yellow-sticky-boards against *Bemisia tabaci*

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Bemisia tabaci is one of the most important greenhouse insect pests in China. It is harmful to many different greenhouse plants. In our research, yellow-sticky-boards and acetamiprid 20% WP were chosen to do the control effect research on *Bemisia tabaci* in greenhouse tomato. Control effects of different hanging height, different substances added to the yellow-board and yellow-board used with acetamiprid were studied. The results showed that the best hanging height in trapping was in the upper part of tomato (bottom of the yellow-sticky-board and the top of the tomato are on the same plane); the yellow-sticky-board that had sexual attractants added showed the best trapping effect (compared with using yellow-sticky-board only or using yellow-sticky-board added with yellow fluorescent agent); yellow-board with sexual attractants used with acetamiprid have a better controlling effect compared with using yellow-board with sexual attractants only or using acetamiprid 20% WP only.

P153 Repetitive overseeding of athletic fields for organic weed management

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Pesticide restrictions on school athletic fields have emerged since 2010, encompassing state-wide bans of conventional pesticides in New York State and Connecticut. Consequently, there is increased pressure to find non-chemical strategies to manage school turf. The feasibility of utilizing overseeding for weed control was tested on eight fields in Central New York (CNY) for three seasons and 40 fields across Maine, Connecticut, and New York for one year over two seasons. The 40 fields were treated three times each season by applying perennial ryegrass seeds to half of each field, except the first year in CNY, which was treated five times the first season. The first treatment was seeded at a rate of 439 kg ha-1 and the second two treatments at 146 kg ha-1. Percent grass, broad leaf weeds, bare soil, soil moisture, soil compaction, shear, and Dark Green Color Index (DGCI) were measured before any treatments were applied and after treatment each season. A generalized linear mixed model was used to analyze the two sets of data. In CNY there was no response to treatment, time, or their interaction, but when analyzing the other 40 fields, percent grass increased as percent broad leaf weeds decreased in the seeded half of field (p-value < 0.05). DGCI, shear, soil moisture, and soil compaction did not respond to treatment, but all decreased with time (p-value < 0.05). The results suggest that repetitive overseeding enhances weed control and improves turf cover on average, but there is inconsistency across regions and individual fields.

P154 Managing virus diseases in vegetable and legume crops in Bangladesh, Cambodia, and Nepal

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Virus diseases are a significant constraint to sustainable production of vegetable and legume crops in subsistence agriculture in developing countries. The Feed the Future Innovation Lab for Integrated Pest Management (IPM-IL) funded by USAID is building epidemiologic intelligence on virus diseases in specific cropping systems in target countries in Asia. Field surveys were conducted in farmers' fields to document the most economically important virus diseases in high-value vegetable and legume crops grown in Bangladesh, Cambodia, and Nepal. Leaf samples showing virus-like symptoms were tested by serological and molecular diagnostic assays. Since serological and molecular diagnostic assays can only detect a specific targeted virus, high-throughput sequencing was used for comprehensive determination of viruses present in symptomatic samples. The most important viruses identified so far include (i) potyviruses *Bean common mosaic virus* in different types of beans, *Zucchini yellow mosaic virus* and *Zucchini tigré mosaic virus* in squash, bottle gourd, bitter gourd and snake gourd, *Chili veinal mottle virus* in chili peppers, and *Potato virus Y* in potato and tomato, (ii) begomoviruses *Tomato leaf curl New Delhi* virus in tomato and potato, *Tomato yellow leaf curl Kanchanaburi* virus in eggplant and tomato, *Bhendi yellow vein mosaic virus* in okra, *Mungbean yellow mosaic virus* in yardlong beans and mungbeans, (iii) the tospovirus *Peanut bud necrosis virus* in tomato, and (iv) the cucumovirus *Cucumber mosaic virus* in eggplant and tomato. This knowledge is incorporated into ecologically-based IPM packages for mitigating crop losses due to virus diseases by resource-poor farmers in Bangladesh, Cambodia and Nepal.

P155 Using multiple plant biostimulants in vegetable systems can increase yields and fruit quality, but not consistently

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Although not universally agreed upon as a definition, a plant biostimulant is any substance or microorganism applied to plants that enhances their nutrition efficiency and abiotic stress tolerance. Growers are always asking if these products are worth using in their vegetable systems. Research over the last several years by the author in vegetable systems has tried to answer that question. When the biostimulents are used alone they performed poorly, i.e., not different from the control. However when combined with other biostimulents their performance at times increased vegetable quality or yields. Combinations such as root applications of mycorrhizae and *Trichoderma harzianum* along with foliar applications of *Beauveria bassiana* strain GHA and *Trichoderma harzianum* or *Streptomyces lydicus* strain WYEC 10 reduced tomato foliar diseases such as bacterial spot and Alternaria spot which

increased yields of marketable tomato fruit. In cantaloupe applications of *Beauveria bassiana* strain GHA and *Streptomyces lydicus* strain WYEC 10 reduced the incidence of bacterial wilt disease although neither product appeared to reduce striped cucumber beetle numbers or feeding damage to the plant. In pumpkins the combination of silicon and seaweed extract decreased powdery and downy mildews as well as Fusarium wilt and significantly increased yields. These positive results at this time are not always consistent, but the cost of applying the products is. Research in vegetable systems will be directed at producing more reliable and consistent results with biostimulents at the most economical costs.

P156 Antagonistic potential of *Bacillus amyloliquefaciens* against major tropical vegetable pathogens

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The study aimed to identify novel antagonistic microorganisms suitable for biological control of diseases in vegetables grown under tropical conditions. Forty-seven *Bacillus* strains isolated from rhizosphere soils of Trinidad were identified as *B. amyloliquefaciens*, *B. subtilis*, *B. pumilus*, *B. cereus*, *B. megaterium*, *B. mycoides*, *B. aryabhattai* based on PCR amplification and PCR sequencing of 16S rRNA gene. All *Bacillus* strains were screened for antibiotic lipopeptide genes *viz*., Iturin A synthetase C (*ituC*), Iturin A synthetase D (*ituD*), Bacillomycin D (*BmyB*) Synthetase, Bacilysin synthetase A (*bacA*), Fengycin synthetase (*fenD*), Surfactin (*SrfC*) and Zwittermycin A (*ZmA*). The study revealed the presence of iturin, bacillomycin, bacilysin, fengycin, surfactin and zwittermycin synthesizing genes in *B. amyloliquefaciens* strains. The phylogenetic tree was generated from the 16s rRNA nucleotide sequences of *Bacillus* strains. Three major groups were observed from the Phylogenetic tree. Group I mainly consisted of *B. aryabhattai* and *B. megaterium*; Group II consisted of *B. cereus*; and *B. pumilus*, *B. subtilis* and *B. amyloliquefaciens* formed Group III, which are identified as major antibiotic producers in this study. The testing of different *Bacillus* species against major vegetable pathogens, *Fusarium oxysporum* f.sp.*lycopersici*, *Colletotrichum gloesporioides*, *Alternaria solani*, *Cercospora lactucae-sativae*, and *Ralstonia solanacearum* under *in vitro* revealed the high antagonistic activity of *B. amyloliquefaciens* strains that showed positive to lipopeptide genes in PCR assay. The study proposed the further testing of lipopeptide producers of *Bacillus* species for the biological control of diseases affecting vegetable production.

P157 Potato Sustainability Initiative: Continuous improvement in sustainable potato production

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The Potato Sustainability Initiative is a collaboration of growers, grower organizations, processors, buyers and the IPM Institute of North America, all working to improve the sustainability of potato production and communicate continuous improvement to buyers. More than 500 growers in the US and Canada currently participate along with six processors, McCain Foods, JR Simplot, Lamb-Weston, Cavendish Farms, Basic American Foods and Kraft-Heinz; two major buyers, McDonalds and Sysco; and the National Potato Council and Canadian Horticultural Council. Our survey originated from an initial request by McDonald's in 2010 to develop a program to track pesticide use, promote IPM practices and measure adoption. The survey has been expanded to include additional best practices to address broader sustainability concerns, and performance metrics for measuring water, nutrient and energy conservation, reuse and recycling, worker and pesticide safety, and greenhouse gas reduction. We have also implemented an audit process so that buyers and consumers can be confident in the results we are communicating.

P158 An IPM approach to reduce wireworm damage in potatoes

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The larvae of the click beetles (Coleoptera: Elateridae), wireworms, are identified as a major pest of potatoes and other vegetable crops worldwide. Over the past ten years, a steady increase in populations of an invasive species *Agriotes sputator* in Prince Edward Island, Canada has resulted in a spread into un-infested crop land. Pheromones were the main approach used to trap adults but mass trapping of male beetles to reduce populations has been unsuccessful. Our objective was to create a trap that would attract both male and female beetles and could be used to reduce populations. A light trap (NELT™) was invented and tested in 2015. The trap consists of a solar powered spotlight, a 16oz glass as a pitfall trap, and a ¼ inch wire cage to prevent large carabid beetles from entering. The traps were placed in two wireworm infested fields in PEI and collected every two days from May 14–July 30. Collected beetles were counted and sexed. Results show significantly higher numbers of male and female beetles in the light traps compared to the controls. A total of 930 beetles (40% females and 60% males) were collected per trap. The trap is

an efficient method of mass trapping females before they lay eggs; this strategy coupled with crop rotation using buckwheat or brown mustard, which has shown to reduce tuber damage by 85% and has been adopted by farmers, and an insecticide during the potato phase has the potential to reduce wireworm populations in infested fields.

P159 Buffering of soil microclimate through soil amendments and mulching has potential in management of insect-vectored virus diseases of tomato

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In the absence of effective strategies for control of tomato virus diseases and their insect vectors, smallholder farmers in Uganda experience high yield losses. The strategy of the research was to focus on boosting the capacity of the plant to tolerate infection and boost natural control through soil-related tactics. Effect of soil amendments from locally accessible materials were studied in relation to insect vector and natural enemy occurrence, virus disease occurrence and severity, and soil improvement. The treatments were coffee husks, cattle manure, straw mulch, plastic mulch, and the untreated control that were laid out in a randomized complete block design with three replications. The experiment was conducted in two consecutive seasons. Results showed that treatments significantly influenced the infestation of whiteflies and reduced viral disease incidence and severity on tomato. Organic soil amendments improved the elements P, K, Ca, Mg, Na, soil organic matter content, and buffered soil temperature, pH and moisture, which culminated into improved yield. Soil temperature was especially important as its correlation with thrips' and whiteflies' infestation, and tomato viral disease incidence and symptom severity were positive and significant. Coffee husks were particularly very effective in buffering soil pH, making this amendment an important liming material especially for smallholder farmers who cannot afford to regularly buy mineral fertilizers. The occurrence of natural enemies was dependent on the amendment used. The results confirmed that when dealing with incurable infections, in this case, virus disease, boosting the soil and plant through nutrition and microclimate conservation can form a foundation upon which other measures can be integrated.

P160 Genome sequencing and development of SNP genotyping assay for identification of *Tuta absoluta*

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Tuta absoluta (*T. absoluta*), originally identified in Peru, is a tomato leafminer that has been confined to South America for over 40 years. It has recently spread to almost every continent, threatening countries whose economies rely heavily on tomato exports. This insect causes crop losses as high as 80 to 100% because it can cause damage to all developmental stages of its host plant. Adult females oviposit on the leaves, where the larva will emerge from the egg and begin mining. Larvae can also enter the stems through the buds and mine within the tomatoes themselves, leaving the fruit unmarketable. Although this moth has yet to be found in the U.S., computer projection models suggest that it will eventually establish in U.S. tomato growing regions, e.g. California, posing a threat to tomato production. Because the damage caused by *T. absoluta* and its morphology are identical to known tomato pests in the U.S., such as the tomato pinworm and the potato tuberworm, identification of this insect remains a challenge. Currently, identification of *T. absoluta* is performed by the dissection of the male genitalia but waiting for the larva to reach its final molt is not practical. We have sequenced the genomes of *T. absoluta*, tomato pinworm, and potato tuberworm and developed a multiplex SNP genotyping assay to distinguish between the three species. This method is fast, reliable, and requires only one individual of any life stage as source material.

P161 Sweet corn pest population trends over 10 years in Maine

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The University of Maine Cooperative Extension initiated a sweet corn IPM program for Maine Farmers in 1983, and it has continued to the present day. Although pest monitoring locations, trap types and pheromone baits have changed over time, a relatively consistent set of data can was extracted from five monitoring sites in the state for past ten years. European corn borer, corn earworm and fall armyworm were the three major corn pests monitored. Of the three, only European corn borer can successfully overwinter in Maine. Corn earworm and fall armyworm come into the state from southern overwintering

sites. Moths of all three species were monitored with pheromone traps, and European corn borer and fall armyworm larvae were also monitored by field scouting. Combining data from the five locations indicates a downward trend for both European corn borer and corn earworm moth captures over the past five years, whereas fall armyworm moth captures have risen over the past five years. Date of first capture each season was slightly more variable for corn earworm moths than for fall armyworm moths, although corn earworm was usually caught one to two weeks earlier. Comparing moth trap captures to larval feeding damage shows a strong relationship in some years at some locations, but poor correlation at others, indicating the importance of field scouting in addition to trapping for moths.

P162 Sweet Corn Scout—A new mobile application to help growers identify and scout for sweet corn pests

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Scouting is one of the cornerstones of Integrated Pest Management (IPM). It informs growers of current pests and whether those pests have reached economic threshold levels. IPM can limit pesticide sprays to times when scouting indicates they are warranted. A survey, conducted in 2013 of NY sweet corn growers, showed that 65% of growers and 75% of consultants that scouted wanted a smart phone application (app) to aid in scouting. This need prompted the development of the Sweet Corn Scout app. This is the latest smart phone app to fall under the NYS IPM Program's Pocket IPM series. Sweet Corn Scout helps identify pests and their typical damage by providing photographs and distinguishing features of the major insect, disease and weed pests found in NY. It also allows for data entry as you scout. It will calculate pest levels and compare them to thresholds. When thresholds are met the app alerts the user and provides links to additional resources on control options.

P163 Evaluation of alternative weed control methods for horticultural crops

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Weed control has been identified by producers as the most critical management concern in organic and sustainable production of horticultural crops. Weed control through cultivation can be labor-intensive and the use of black plastic mulch creates substantial waste and entails costs for purchase, removal and disposal. Kaolin clay has previously been identified as a weed control material, known as particle film mulch; however, few studies have investigated the use of this material in horticultural crops. This study aimed at comparing 5 alternative weed control treatments against an un-weeded control in field production of bell peppers in eastern Missouri. The treatments include dry kaolin clay, kaolin clay slurry, D-limonene herbicide (a citrus-based extract) at two rates, and wheat straw. Dry kaolin clay, kaolin clay slurry and wheat straw were applied at the time of pepper planting, and D-limonene herbicide was applied bi-weekly to visible weeds, beginning two weeks after planting. Treatments were evaluated bi-weekly for ground cover density of weeds and weekly for total fruit weight and number of fruit. Weeds were harvested at the completion of the study and dry weights recorded for all treatments and control. Results of this study show that all treatments, excluding dry kaolin clay, significantly suppressed weeds in comparison to the un-weeded control for the duration of the field study, although no treatment effects on yield were detected.

P164 not being presented

P165 Successful adoption of action threshold-based insecticide programs for thrips management in onion

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Onion thrips (*Thrips tabaci*) is one of the most significant insect pests of onion, which is a high-value and intensively grown crop. Previous research has shown that onion thrips can be effectively managed in onion using insecticides applied following an action threshold of one thrips per leaf. However, recent survey results revealed only 50% of New York onion growers are using action thresholds. In a three-year case study, Cornell Entomologists and Cornell Cooperative Extension Vegetable Specialists deployed an onion thrips scouting program, in which growers received weekly data on onion thrips densities in their fields, and a corresponding recommendation based on the action threshold. From 2015 to 2017, there was a 48% increase in grower adoption of the action threshold (50% to 74%). Onion growers who used action thresholds successfully controlled onion thrips densities, and made between 2-4 fewer insecticide applications compared with those growers who did not use action thresholds. Cost savings from using the action threshold recommendations averaged $42/acre. In the exit survey, growers' risk perception and satisfaction with a weekly (non-threshold based) insecticide program were the primary reasons they ignored action threshold recommendations. In contrast, growers who regularly used action thresholds cited concerns about insecticide resistance as the primary reason for adopting thresholds. This case study serves as evidence that intensive interactions between growers and extension/

university researchers has the potential to increase the adoption of integrated pest management tactics in high-value commodities.

P166 Making rational pest management decisions for organic production of *amaranthus* in North Carolina

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Amaranthus is a leafy vegetable and grain commodity popular among immigrants in the US and other peoples worldwide. It is commonly attacked by insects that cause significant yield reduction. The aim of this study was to (a) screen varieties for resistance to the major pests of this crop under two cropping systems, with/without a compost mulch; (b) screen for best biorational insecticides that can be used with resistant varieties for synergistic insect control in the two systems in (a). Nine *Amaranthus* varieties were used. Field and laboratory studies were conducted to determine pest responses and the biochemical differences that may help to explain any resistance observed. We recorded pests from five orders: Hemiptera, Diptera, Coleoptera, Hymenoptera, and Lepidoptera. *Disonycha glabrata* (the pigweed flea beetle) was the dominant pest in both systems. Overall combined insect populations were as follows: no mulch = 2761; mulch =1549. However, mulched plots had the highest seasonal average of *D. glabrata* (1015.7 ± 27.44; no mulch=577.7 ± 14.10) (P20-40; 3= >40-60; 4: >60-80; 5= > 80-100%) was as follows: Green Callaloo (3.7), Mayo India (3.5), Molten Fire (1.1), Red Garnet (1.2). Analytical differences exist in allelochemical composition among amaranth varieties. These may explain the differences in the observed herbivory. Entrust® gave good control of *D. glabrata* under field conditions, while Pyganic® and Ecotec® were more effective in laboratory assays. These findings will be used to develop a sustainable pest management strategy appropriate for organic *Amaranthus* production.

P167 Aphid tower trapping results in Maine

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A series of five, sixteen-foot tall towers with four six inch by twelve-inch yellow sticky cards, placed at each of the four compass points at both sixteen and six feet, has been established in the potato producing area of Aroostook County, Maine. Cards from these towers are collected once per week and the aphids trapped are identified to species. The date of collection, direction and height of the collected aphid are recorded. Trapping is initiated prior to potato crop emergence so that the initial aphid flights of the various species can be detected. There is significant variation in the magnitude of collections of different species from year to year. There are also great variations when the initial occurrence of certain species occurs from year to year and there are great consistencies in the initial occurrence of several aphid species, which have the potential to transmit non-persistent viruses to potatoes such as Potato Virus Y. The occurrence of these species is predictable. This information can be used by potato growers to assist the timing of control strategies.

P168 Promoting sustainable, biologically-based pest management systems for improved vegetable production in high tunnels

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High tunnels, also called hoop houses, are single-span to multi-span structures usually covered in a single layer of 6-mil polyethylene greenhouse film. Due to the lack of electrical utilities, high tunnels are passively heated and cooled, relying on solar radiation for heating and passive ventilation for cooling. They offer great opportunities for low-cost protected vegetable production, but they also present unique pest management challenges. Aphids, whiteflies, spider mites, and thrips represent the main arthropod pests of high-tunnel grown tomatoes. Aphids, harlequin bugs, and various caterpillar species are commonly associated with Brassicas. These pests reduce yield, crop quality, and ultimately income. To combat arthropod pests organic farmers have limited tools most of which are expensive and some of which are non-specific to the target pests. Over a 3-year period, the Lincoln University IPM program implemented Extension and on-farm demonstration projects aimed at promoting biologically-based pest management systems that integrate trap cropping (attractive plants that are planted next to a higher value crop so as to attract the pest) with biological control through the use of selected insectary plants. Nine producers evaluated the biologically-based IPM systems, which were adjusted accordingly based on their type of operation. All producers were supplied with trap crop and insectary plant seeds or seedlings, and some producers were provided with predatory insects and parasitic wasps. Short- and mid-term outcomes were documented.

P169 Developing an attract and kill approach for harlequin bug, *Murgantia histrionica* (Hemiptera: Pentatomidae).

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Harlequin bug (HB), *Murgantia histrionica* (Hemiptera: Pentatomidae), can be disruptive of cole crop IPM, because abundant populations prompt use of broad-spectrum pesticides. New and selective tools are needed for vegetable growers to manage this bug. The combination of insect and plant stimuli creates an attractive lure which could be used as part of an "attract and kill" approach for HB management. Both sexes of adult harlequin bug, as well as the nymphs, are attracted to its male-produced pheromone, murgantiol. Collard plants attract and accumulate ~50-fold more bugs when baited with the mixed pheromone preparation, than when the pheromone lure is absent. Using murgantiol and collard plants (*Brassica oleracea* 'Champion') to attract insects to a "trap," we evaluated two methods of retaining HB thereby avoiding damage to nearby cole crops: poisoning the trap plant with a systemic neonicotinoid and surrounding the trap plant with long lasting insecticide netting impregnated with a fast acting contact insecticide (deltamethrin).

P170 Capacity building in small farm IPM at Alcorn State University

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Small farmers in the southeastern United States face serious challenges in managing plant diseases, and insects in vegetable crops. Yield loss due to plant pests can be substantial. Many reports have addressed the need to provide more training and experiential learning in plant health management at the U.S. Land grant universities to counter the threat of plant pests to our crop production systems. Alcorn is implanting a novel approach in integrating our research, education, and extension programs to create a niche in serving small farmers in Mississippi. Leveraging on this strength, a team of plant health faculty at Alcorn consisting of entomologist, mycologist, plant pathologist and virologist are developing IPM strategies for sustainable crop production for small-farms. Some ongoing activities include phylogenetic analysis of *Alternaria alternata*, *Alternaria tenuissima* and *Alternaria cheiranthi* populations infecting vegetable crops, isolation and characterization of *Trichoderma* spp. for use as biological control agents for soil-borne plant pathogens, management of plant viruses affecting vegetables, evaluating purple sticky traps as a viable monitoring tool for insect pests of sweet potatoes (*Ipomoea batatas*), and establishing trap crop demonstration plots for managing insect pest of vegetables. To enhance IPM education we have created new classes in entomology and plant pathology. Major impacts of this project include increased awareness and knowledge of IPM to over 200 farmers, 3,000 K-12 students, 300 graduate and undergraduate students, via, workshops, symposia, short courses, field days, and community gardening.

P171 Living mulch as a tool for integrated weed management in organic vegetables

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Organic vegetable farmers rely on tillage and cultivation as tools to control weeds, which can increase production costs and negatively impact soil health. Growing organic vegetables under reduced tillage is made even more difficult because of a lack of effective and affordable herbicides labelled for organic use. Living mulches may be incorporated into integrated weed management programs to suppress weeds throughout the growing season, potentially allowing vegetable crops to be grown under reduced tillage. Here, we present data from a three-year project testing whether red clover (*Trifolium pretense*), used as a living mulch, can provide season-long suppression of weeds in a bell pepper (*Capsicum annuum*) crop. Our experiment tests the living mulch against dead, organic mulch from a fall-planted mixture of rye (*Secale cereale*) and crimson clover (*Trifolium incarnatum*) cover crops. Data were collected on weed species and abundance, persistence of different types of mulch, plant performance, and yield quantity and quality. Our hypothesis is that the dead organic mulches will degrade over time, resulting in decreased weed suppression later in the season, while the red clover will continue to suppress weeds for the duration of the pepper crop. Results from this study will determine whether living mulches can offer an additional tool to for developing integrated weed management strategies in organic vegetables.

PI72 Evaluation of host preference of brown marmorated stink bug, *Halyomorpha halys*, on bell peppers

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Brown marmorated stink bug (BMSB), *Halyomorpha halys* (Stål), (Hemiptera: Pentatomidae), a highly polyphagous invasive pest from Asia has become a major agricultural pest in the US. Laboratory experiments were conducted to determine nymph and adult BMSB preference for bell peppers of different colors (red, yellow, green and orange). Peppers were presented to BMSB using Dual Choice Arena Test (DCAT)—cowpea pod as standard and Multiple Choice Arena test (MCAT). Both DCAT and MCAT were video recorded. A 4-arm olfactometer test was conducted—each pepper color in each arm. From data collected Preference Index (PI), percentage distribution and time spent on each pepper were calculated. In DCAT, nymphs preferred red-pepper (PI=1.5) and yellow least (PI=1.2). Adults preferred green (PI=1.5) and red (PI=1.5) and orange least (PI=1.3). Overall, both nymphs and adults preferred peppers over cowpea. In MCAT, BMSB distribution among peppers was not significantly different ($P<0.05$) between nymphs and adults. In MCAT adult distribution on orange, red, green and yellow peppers was 32%, 24%, 23% and 19% respectively compared to 38%, 27%, 20% and 10% for red, yellow, orange and green respectively for olfactometer. This difference could be due to attraction to plant volatiles as opposed to direct contact. From 30mins. video recording BMSB spent 55%, 33%, 9% and 3% time on red, orange, yellow and green peppers respectively. The differences in preferences may point to difference in nutritional requirements of BMSB and chemical composition of different color peppers.

PI73 Effect of *trichoderma* species on emergence indices, infection incidence and growth performance of sweet pepper

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This study investigated effectiveness of three *Trichoderma* species in controlling damping off disease caused by Pythium aphanidermatum in sweet pepper seedlings and also evaluated their contribution to overall growth performance and emergence indices in sweet pepper seedlings. Sweet pepper seeds treated with 2.5 x 10 6 conidia/ ml of *Trichoderma harzianum*, *Trichoderma atroviride* and *Trichoderma koningii* were sown to determine the emergence percentage at 7 Days after planting (DAP), 9 DAP and 14 DAP. Emergence Index and Emergence Rate Index were computed for each *Trichoderma* treatment. Data on plant growth parameters and disease incidence percentage were measured on 30 day old seedlings inoculated with 5 X 105 spores/ ml *Pythium aphanidermatum* at 15-day old sweet pepper seedlings. Seedlings of sweet pepper treated with both *Trichoderma atroviride* and *Trichoderma harzianum* had higher emergence percentage than the un-treated seedlings, which was not significantly lower in emergence percentage from *Trichoderma koningii* treated pepper seedlings. The presence of these *Trichoderma* species in *P. aphanidermatum* infected sweet pepper seedlings, reduced disease incidence significantly. Higher seedling vigour assessments and improved growth rates were recorded on 30 day old seedlings when treated with *Trichoderma* species either with or without *P. aphanidermatum* were observed, especially in *T. atroviride* plus pathogen. *Trichoderma* species, when presence enhance the growth of the developing plant root system viz-a viz the plant growth and yield through better nutrient uptake, production of growth promoting compounds and solubilization of phosphates, micronutrients and mineral cations like iron, manganese and magnesium necessary for plant metabolism.

PI74 Resistance of genetically-diverse soybean varieties to insect pests in the eastern shore of Maryland

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The use of resistant soybean, *Glycine max* (L.) cultivars against insect pests reduces chemical insecticide usage, resulting in minimum risk to the environment and increased grower profits. The main objective of this study was to compare the resistance of soybean varieties against insect pests. First, a field experiment was conducted in a randomized block design with four soybean varieties (Varity1 -SG13#3, Variety 2 (F5-SS-1#5), Variety 3 (GH12-1-1), and Variety 4 (TARA), with four replications each. Insect pests were sampled using sweep-net sampling, and the number of caught insects was recorded. The level of leaf and stem damage was also recorded and correlated with the number of insect species trapped in the net. Second, a laboratory feeding bioassay was performed using leaf cuttings from the four soybean verities for three consecutive days. A high number of insect pests were observed in variety 4 followed by variety 3, and the number of trapped insects was highly correlated with damage levels reported in these varieties. Varieties 1 and 2 were relatively resistant compared to varieties 3 and 4. After 3 days, beet armyworm caterpillars had fed on 64% of soybean variety 4 leaves, but only 54%, 58% and 56% of leaves of varieties 1, 2 and 3 respectively. Laboratory results were consistent with field results. The caterpillars fed less on variety 1; this variety might have some toxic secondary metabolite that deters the insect pests. This research should be repeated next season to confirm the outcomes of the current study.

P175 Pests: An unwanted side effect of tropical storms

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After two Category 5 hurricanes, Irma and Maria, made their way over the Virgin Islands in September 2017, pest populations spiked. Some reasons for pest increases include: heavy rains, decay and bad odors that support moisture-loving flies, biting midges, and mosquitoes; displaced and wandering pests seek out new grounds to live, if they survive. The Jack Spaniard showed anger and stung people as debris was being picked up, and now there is no sign of the wasp. Leaf-less palms and plants released chemicals of stress that attract pests; certain environmental conditions favor pest explosions; and natural enemies blown away so unable to keep pests under control. Locals reached out to the Cooperative Extension Service concerned that their plants were quickly consumed by an assortment of furry visitors; an over-abundance of fungus gnats swarmed inside homes, attracted to lights run by generators; dark-colored 'loopers' devastated newly-leafed flamboyant trees, fanciful striped caterpillars stripped frangipani; black and yellow larvae ate flowers of sun hemp causing no seed production; and numerous cockroaches multiply in sewer drains. As if virgin island victims without roofs didn't have enough to deal with, unfortunately there were more pest issues added to the overall trouble brought upon by two hurricanes.

P176 Alternative avoidance method of insecticide resistance using egg parasitoid to block rotation, periphery zone treatment

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In June of 2014, high parasitism cumulative from 6th to 15th (98 adults/100 eggs), of Anaphes nipponicus for Oulema oryzae's egg was observed in paddy fields treated with Fipronil 8 time from 2002 to 2012, in which there were laying eggs not to be hatched. Oulema oryzae is an index pest insect for insecticides resistance. When the systemic insecticide treatments be successively done more than 6 times at least, the insecticide resistance adults begin to appear. The light restoration is born of detoxification to the inhibition substances of DNA & protein synthesis in fat body surrounding ovary of the feeding adults overwintered. The oogenesis under the sub-lethal toxicity could cease the following embryogenesis to early embryonic stage before blastoderm on which egg parasitoids are available for parasitism & development. Therefore, all eggs are existing as a target of egg parasitoid, following high parasitism. This symptom have been also coming out in the other systemic insecticide. If the sensitive population is comparable with the resistance population by mean of partial control using egg parasitoids, there are an avoidance of insecticide yet. In paddy fields, I would like to recommend the periphery zone treatment of the same systemic insecticide, using egg parasitoid. The other hand, in the areas out of the partial control using egg parasitoid, the completion of insecticide resistance on honey bee will be surely achieved by the continuous use of same chemical over the future.

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Note—*Numbers preceded by a "P" indicate a poster; other numbers refer to oral sessions.*

map of meeting space

FIFTH FLOOR