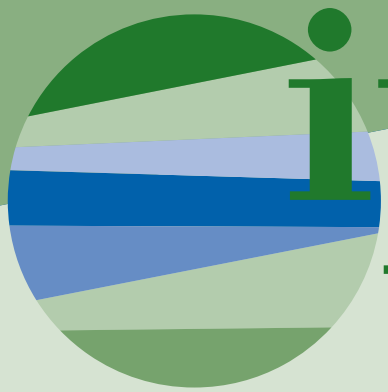

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8th International

Integrated Pest Management Symposium

IPM: Solutions for a Changing World

March 23–26, 2015

Salt Lake City, Utah

welcome

IPM: Solutions for a Changing World

Welcome to the 8th international IPM Symposium. Building on a tradition of nearly 30 years, this event once again brings together a rich and diverse group of IPM professionals from around the world to share their successes in finding IPM solutions in a changing world.

This symposium offers opportunity to join our colleagues from around the world to hear about the latest research, discover new solutions for IPM, and connect with old friends and new colleagues. The all-volunteer planning committees have worked tirelessly over the past three years to bring you this event in Salt Lake City. The program is structured so that you can take in all events that interest you. Keynote addresses from IPM leaders will stimulate and invigorate discussion. Breakout and poster sessions are organized in tracks based on commodity or setting to address various aspects of IPM across disciplines and around the world. We will honor those for their achievements in IPM. Local field trips and professional seminars have been developed to enhance your IPM expertise.

With the backdrop of the Wasatch Mountains, we hope that you enjoy all that Salt Lake City has to offer from many cultural and historical sites to shopping venues to exploring the Clark planetarium.

Thank you to all of our sponsors, contributors, organizers, moderators, presenters, and participants for making the 8th International IPM Symposium a reality. The success of this event is a result of your support.

Welcome and enjoy!

Margaret Appleby, Naresh Duggal, Rubella Goswami, Jill Schroeder
Co-chairs, 8th International IPM Symposium

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Contents

8th International IPM Symposium
coordinated by Center for Innovation
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Exhibitors

Exhibits are located in Hall 1, on the ground level of the Salt Palace Convention Center. Poster sessions, continental breakfasts, and breaks will be served in the exhibit room.

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committees

Steering Committee

Margaret Appleby, margaret.appleby@ontario.ca, Ontario Ministry of Agriculture, Food and Rural Affairs, Brighton, ON, Canada, Co-Chair

Naresh Duggal, Naresh.Duggal@ceo.sccgov.org, IPM, Santa Clara County, San Jose, CA, Co-Chair

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Jill Schroeder, Jill.schroeder@ars.usda.gov, United States Department of Agriculture Office of Pest Management Policy, Washington, DC, Co-Chair

Anastasia Becker, anastasia.becker@mda.mo.gov, Integrated Pest Management Bureau, Missouri Department of Agriculture, Jefferson City, MO

Denise T. DeBusk, denise.debusk@navy.mil, Naval Facilities Engineering Command, Atlantic, Norfolk, VA

Dawn H. Gouge, dhgouge@email.arizona.edu, Department of Entomology, College of Agriculture and Life Science, University of Arizona, Maricopa, AZ

Thomas A. Green, ipmworks@ipminstitute.org, IPM Institute of North America, Inc., Madison, WI

Jean Haley, jahaley@illinois.edu, North Central IPM Center, University of Illinois, Urbana, IL

Janet Hurley, ja-hurley@tamu.edu, Texas A&M AgriLife Extension Service, Dallas, TX

Lynnae Jess, jess@msu.edu, North Central IPM Center, Michigan State University, East Lansing, MI

Norman C. Leppla, nclеppla@ufl.edu, Entomology and Nematology, University of Florida, Gainesville, FL

Megha N. Parajulee, m-parajulee@tamu.edu, Texas A&M AgriLife Research and Extension Center, Lubbock, TX

Elaine Wolff, wolff1@illinois.edu, Center for Innovation in Teaching & Learning, University of Illinois at Urbana-Champaign, Urbana, IL

Awards Committee

Janet Hurley, ja-hurley@tamu.edu, Texas A&M AgriLife Extension Service, Dallas, TX, Co-Chair

Megha N. Parajulee, m-parajulee@tamu.edu, Texas A&M AgriLife Research and Extension Center, Lubbock, TX, Co-Chair

Susan Cohen, sdcohen50@gmail.com, Center for Regulatory Research, LLC, White Bear Lake, MN

Ted E. Cottrell, ted.cottrell@ars.usda.gov, USDA-Agricultural Research Service, Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA

Martin Draper, mdraper@nifa.usda.gov, USDA-NIFA, Washington, DC

Muhammad Haseeb, Muhammad.Haseeb@famu.edu, Center for Biological Control (CBC), College of Agriculture and Food Sciences (CAFS), Florida A&M University (FAMU), Tallahassee, FL

Janet Knodel, janet.knodel@ndsu.edu, North Dakota State University Extension Service, Fargo, ND

Shujuan (Lucy) Li, lisj@cals.arizona.edu, MAC, University of Arizona, Maricopa, AZ

Shaku Nair, nairs@email.arizona.edu, MAC, University of Arizona, Maricopa, AZ

Silvia I. Rondon, silvia.rondon@oregonstate.edu, Department of Crop and Soil Sciences, Oregon State University, Hermiston Agriculture Research and Extension Center, Hermiston, OR

Finances/Exhibits Committee

Thomas A. Green, ipmworks@ipminstitute.org, IPM Institute of North America, Inc., Madison, WI , Co-Chair

Jean Haley, jahaley@illinois.edu, North Central IPM Center, University of Illinois, Urbana, IL, Co-Chair

Anastasia Becker, anastasia.becker@mda.mo.gov, Integrated Pest Management Bureau, Missouri Department of Agriculture, Jefferson City, MO

David Henderson, dhenders@springisd.org, Spring Independent School District, Houston, TX

Chloe L. Nelson, cnelson@ipminstitute.org, IPM Institute of North America, Inc., Madison, WI

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

Local Arrangements Committee

Diane G. Alston, diane.alston@usu.edu, Department of Biology, Utah State University, Logan, UT

Ryan S. Davis, ryan.davis@usu.edu, Department of Biology, Utah State University, Logan, UT

Michael G. Pace, mike.pace@usu.edu, Utah State University Extension, Brigham City, UT

Ricardo Ramirez, ricardo.ramirez@usu.edu, Department of Biology, Utah State University, Logan, UT

Gregg Smith, Gregg.Smith@slcschools.org, Salt Lake City School District, Salt Lake City, UT

Lori R. Spears, lori.spears@usu.edu, Department of Biology, Utah State University, Logan, UT

Katie Wagner, katie.wagner@usu.edu, Salt Lake County Extension, Utah State University, Salt Lake City, UT

Media/Outreach Committee

Diane G. Alston, diane.alston@usu.edu, Department of Biology, Utah State University, Logan, UT

Hannah Burrack, hannah_burrack@ncsu.edu, North Carolina State University, Raleigh NC

Sherry Glick, glick.sherry@epa.gov, EPA/Office of Pesticide Programs, Dallas, TX

Janet Knodel, janet.knodel@ndsu.edu, Department of Plant Pathology, North Dakota State University, Fargo, ND

Sherri Novack, novack@aesop.rutgers.edu, The IR-4 Project, Rutgers University, Princeton, NJ

Mary K. Malinoski, mkmal@umd.edu, University of Maryland Extension, University of Maryland, Ellicott City, MD

Glenn Studebaker, gstudebaker@uaex.edu, University of Arkansas Division of Agriculture, Northeast Research and Extension Center, Keiser, AR

Lori R. Spears, lori.spears@usu.edu, Department of Biology, Utah State University Logan, UT

Cheryl Wilen, cawilen@ucanr.edu, University of California Cooperative Extension, San Diego, CA

Operations/Website Committee

Denise T. DeBusk, denise.debusk@navy.mil, Naval Facilities Engineering Command, Atlantic, Norfolk, VA, Co-Chair

Diane G. Alston, diane.alston@usu.edu, Department of Biology, Utah State University, Logan, UT

Carrie R. Foss, cfoss@wsu.edu, WSU Urban IPM & Pesticide Safety Education, WSU Puyallup, Puyallup, WA

Sherry Glick, glick.sherry@epa.gov, EPA/Office of Pesticide Programs, Dallas, TX

Lori R. Spears, lori.spears@usu.edu, Department of Biology, Utah State University Logan, UT

Posters Committee

Anastasia Becker, anastasia.becker@mda.mo.gov, Integrated Pest Management Bureau, Missouri Department of Agriculture, Jefferson City, MO, Chair

Margaret Appleby, margaret.appleby@ontario.ca, Ontario Ministry of Agriculture, Food and Rural Affairs, Brighton, ON, Canada

Ted E. Cottrell, ted.cottrell@ars.usda.gov, USDA-Agricultural Research Service, Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA

Muhammad Haseeb, Muhammad.Haseeb@famu.edu, Center for Biological Control (CBC), College of Agriculture and Food Sciences (CAFS), Florida A&M University (FAMU), Tallahassee, FL

Glenn Studebaker, gstudebaker@uaex.edu, University of Arkansas Division of Agriculture, Northeast Research and Extension Center, Keiser, AR

Programs Committee

Dawn H. Gouge, dhgouge@email.arizona.edu, Department of Entomology, College of Agriculture and Life Science, University of Arizona, Maricopa, AZ, Co-Chair

Lynnae Jess, jess@msu.edu, North Central IPM Center, Michigan State University, East Lansing, MI, Co-Chair

Norman C. Leppla, ncleppla@ufl.edu, Entomology and Nematology, University of Florida, Gainesville, FL, Co-Chair

Nick Birch, nick.birch@hutton.ac.uk, James Hutton Institute, Dundee, Angus, Scotland, U.K.

Lynn Braband, lab45@cornell.edu, New York State IPM Program, Cornell University, Rochester, NY

Ted E. Cottrell, ted.cottrell@ars.usda.gov, USDA-Agricultural Research Service, Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA

Denise T. DeBusk, denise.debusk@navy.mil, Naval Facilities Engineering Command, Atlantic, Norfolk, VA

D. Seth Dibblee, dibblee.seth@epa.gov, US EPA - Region 5, Chicago, IL

Naresh Duggal, Naresh.Duggal@ceo.sccgov.org, IPM, Santa Clara County, San Jose, CA

Brian C. Eshenaur, bce1@cornell.edu, IPM Program, Cornell University, Ithaca, NY

Sherry Glick, glick.sherry@epa.gov, EPA/Office of Pesticide Programs, Dallas, TX

Gary L. Hein, ghein1@unl.edu, Doctor of Plant Health, University of Nebraska, Lincoln, NE

Janet Hurley, ja-hurley@tamu.edu, Texas A&M AgriLife Extension Service, Dallas, TX

Modesto Olanya, modesto.olanya@ars.usda.gov, USDA-Agricultural Research Service, Eastern Regional Research Center, Wyndmoor, PA

Megha N. Parajulee, m-parajulee@tamu.edu, Texas A&M AgriLife Research and Extension Center, Lubbock, TX

Site Selection Committee

Joy N. Landis, landisj@msu.edu, Integrated Pest Management Program Office, Department of Entomology, Michigan State University, East Lansing, MI, Co-Chair

David Clement, clement@umd.edu, University of Maryland Extension, Ellicott City, MD

Martin Draper, mdraper@nifa.usda.gov, USDA-NIFA, Washington, DC

Amer Fayad, afayad@vt.edu, Office of International Research, Education, and Development (OIRED), Virginia Polytechnic Institute and State University, Blacksburg, VA

Sherry Glick, glick.sherry@epa.gov, EPA/Office of Pesticide Programs, Dallas, TX

David Henderson, dhenders@springisd.org, Spring Independent School District, Houston, TX

Lynnae Jess, jess@msu.edu, North Central IPM Center, Michigan State University, East Lansing, MI

Mary K. Malinoski, mkmal@umd.edu, University of Maryland Extension, University of Maryland, Ellicott City, MD

Daren S. Mueller, dsmuelle@iastate.edu, Department of Entomology, Iowa State University, Ames, IA

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

session organizers

Charles Allen, ctallen@ag.tamu.edu, Texas A&M AgriLife Research and Extension Center, San Angelo, TX

Kwesi Ampong-Nyarko, kwesi.ampong-nyarko@gov.ab.ca, Edmonton Special Crops, Alberta Ag and Rural Development, Edmonton, Alberta, Canada

Thomas A. Babb, thomas.babb@cdpr.ca.gov, Pest Management and Licensing Branch, California Department of Pesticide Regulation (California EPA), Sacramento, CA

Jonathon M. Babcock, jmbabcock@dow.com, Crop Protection Research and Development, Dow AgroSciences, Indianapolis, IN

Dan Badulescu, columbus@columbus-grp.com, H&A Columbus Development, Ltd, Vancouver, BC, Canada

George G. Bernardon, george.bernardon@sscserv.com, Grounds Management, SSC Service Solutions, Knoxville, TN

Alisha Bower, abower@ipminstitute.org, IPM Institute of North America, Inc., Madison, WI

Lynn Braband, lab45@cornell.edu, New York State IPM Program, Cornell University, Rochester, NY

Jeff Bradshaw, jbradshaw2@unl.edu, Dept of Entomology, University of Nebraska, Scottsbluff, NE

Diania Caudell, diacaudell@aol.com, California Indian Basketweavers Association, Escondido, CA

Fred Corey, fcorey@micmac-nsn.gov, Aroostook Band of Micmacs, Presque Isle, ME

Andrew G.S. Cuthbertson, andrew.cuthbertson@fera.gsi.gov.uk, The Food and Environment Research Agency, National Bee Unit, Sand Hutton, York, UK

Surendra K. Dara, skdara@ucdavis.edu, Division of Agriculture and Natural Resources, University of California Cooperative Extension, San Luis Obispo, CA

Denise T. DeBusk, denise.debusk@navy.mil, Naval Facilities Engineering Command, Atlantic, Norfolk, VA

Anita Dille, dieleman@ksu.edu, Agronomy Department, Kansas State University, Manhattan, KS

Naresh Duggal, Naresh.Duggal@ceo.sccgov.org, IPM, Santa Clara County, San Jose, CA

Megan Dunn, mdunn@pesticide.org, Northwest Center for Alternatives to Pesticides (NCAP), Everett, WA

Donna Ellis, donna.ellis@uconn.edu, Department of Plant Science & Landscape Architecture, University of Connecticut, Storrs, CT

Brian C. Eshenaur, bce1@cornell.edu, IPM Program, Cornell University, Ithaca, NY

Amer Fayad, afayad@vt.edu, Office of International Research, Education, and Development (OIRED), Virginia Polytechnic Institute and State University, Blacksburg, VA

Christopher J. Fettig, cfettig@fs.fed.us, USDA Forest Service, Davis, CA

Amy Fulcher, afulcher@utk.edu, Department of Plant Sciences, University of Tennessee, Knoxville, TN

Susan Futrell, sfutrell@redtomato.org, Red Tomato, Plainville, MA

Jody L. Gangloff-Kaufmann, jlg23@cornell.edu, New York State IPM Program, Cornell University, Babylon, NY

Mary Gardiner, gardiner.29@osu.edu, Entomology, The Ohio State University, Wooster, OH

Sherry Glick, glick.sherry@epa.gov, EPA/Office of Pesticide Programs, Dallas, TX

Thomas A. Green, ipmworks@ipminstitute.org, IPM Institute of North America, Inc., Madison, WI

Nina Hapner, nina@stewartspoint.org, Kashia Band of Pomo Indians, Stewarts Point Rancheria, Santa Rosa, CA

Gary L. Hein, ghein1@unl.edu, Doctor of Plant Health, University of Nebraska, Lincoln, NE

Amanda C. Hodges, achodges@ufl.edu, Doctor of Plant Medicine, University of Florida, Gainesville, FL

Paul A. Horne, paul@ipmtechnologies.com.au, IPM Technologies Pty Ltd, Hurstbridge, Victoria, Australia

Janet Hurley, ja-hurley@tamu.edu, Texas A&M AgriLife Extension Service, Dallas, TX

James Jasinski, jasinski.4@osu.edu, Extension, Ohio State University, Urbana, OH

Cezarina Kora, Cezarina.Kora@agr.gc.ca, Pesticide Risk Reduction Program, Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada

Per Kudsk, per.kudsk@agro.au.dk, Agroecology, Aarhus University, Slagelse, Denmark

Anthony V. LeBude, anthony_lebude@ncsu.edu, Department of Horticultural Science, N.C. State University, Mills Rivers, NC

Norman C. Leppla, ncleppla@ufl.edu, Entomology and Nematology, University of Florida, Gainesville, FL

Tracy Leskey, Tracy.Leskey@ARS.USDA.GOV, USDA, Kearneysville, WV

Ian MacRae, imacrae@umn.edu, Dept of Entomology, University of Minnesota, Crookston, MN

Agenor Mafra-Neto, president@iscatech.com, ISCA Technologies Inc., Riverside, CA

Mary K. Malinoski, mkmal@umd.edu, University of Maryland Extension, University of Maryland, Ellicott City, MD

Catharine Mannion, cmannion@ufl.edu, Tropical Research and Edu Center, University of Florida, Homestead, FL

Robert A. Masters, ramasters@dow.com, Crop Protection Research and Development, Dow AgroSciences, Indianapolis, IN

Ray McAllister, ray@croplife.us, CropLife America, Washington, DC

Debby F. Mir, debbymir@gmail.com, Tel-Aviv University, Tivon, Israel

Rangaswamy Muniappan, rmuni@vt.edu, Office of International Research, Education, and Development (OIRED), Virginia Polytechnic Institute and State University, Blacksburg, VA

Kathy D. Murray, kathy.murray@maine.gov, Maine Department of Agriculture, Conservation and Forestry, Augusta, ME

Shaku Nair, nairs@email.arizona.edu, MAC, University of Arizona, Maricopa, AZ

Micheal D.K. Owen, mdowen@iastate.edu, Agronomy Department, Iowa State University, Ames, IA

Palle Pedersen, palle.pedersen@syngenta.com, Seedcare, Syngenta, Stanton, MN

John Phillips, jphillips@aihec.org, First Americans Land Grant Consortium, Watkinsville, GA

Jawwad A. Qureshi, jawwadq@ufl.edu, Southwest Florida Research and Education Center, University of Florida-IFAS, Immokalee, FL

Richard Raid, rnraid@ufl.edu, Plant Pathology, University of Florida, Belle Glade, FL

Gadi V.P. Reddy, reddy@montana.edu, Western Triangle Ag Research Center, Montana State University, Conrad, MT

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

Cesar Rodriguez Saona, CRodriguez@AESOP.Rutgers.edu, Rutgers, Chatsworth, NJ

James E. Sargent, sarge@copesan.com, Copesan Services, Menomonee Falls, WI

Maurizio Sattin, maurizio.sattin@ibaf.cnr.it, Instituto di Biologia Agroambientale e Forestale, CNR, Legnaro, Italy

Melissa Willrich Siebert, mwillrichsiebert@dow.com, Crop Protection R&D, Dow AgroSciences LLC, Indianapolis, IN

Michael C. Shaw, mcshaw@dow.com, Global Product Development, Dow AgroSciences LLC, Indianapolis, IN

Chris J. Stelzig, cstelzig@entsoc.org, Director of Certification, Entomological Society of America, Annapolis, MD

Bill Stoneman, bstoneman@biopesticideindustryalliance.org, Biopesticide Industry Alliance, McFarland, WI

Allison Taisey, ataisey@pestworld.org, National Pest Management Association, Fairfax, VA

Vaughn Walton, vaughn.walton@oregonstate.edu, Oregon State University, Corvallis, OR

Changlu Wang, cwang@aesop.rutgers.edu, Entomology, Rutgers University, New Brunswick, NJ

Tim Weigle, thw4@cornell.edu, NYS IPM Program, Cornell University, Portland, NY

Sarah A. White, swhite4@clemson.edu, School of Agricultural, Forest, & Environmental Sciences, Clemson University, Clemson, SC

Julianna K. Wilson, jkwilson@msu.edu, Entomology, Michigan State University, East Lansing, MI

Robert Wright, rwright2@unl.edu, Entomology, University of Nebraska-Lincoln, Lincoln, NE

Steve Young, sly27@cornell.edu, Northeastern IPM Center, Cornell University, Ithaca, NY

general information

Registration and Information Desk

The Registration Desk will be located in Hall 1, on the ground level of the Salt Palace Convention Center.

The desk will be open:

Monday, March 23, 12:00–5:00 PM

Tuesday, March 24, 7:00 AM–5:00 PM

Wednesday, March 25, 7:30 AM–5:00 PM

Thursday, March 26, 7:30 AM–5:00 PM

A visitor information desk and a visitor gift shop are located in the South Foyer of the Salt Palace Convention Center.

Wireless Access

You can access two different networks:

- In the lower lobby (outside Hall1-4), look for network name: SP Free. No password needed, but you will need to enter your name to generate an account.
- Inside Hall1, rooms 155 and 355, look for the network name: IPMSymposium. Password is: promoteIPM2015.

IPM Symposium 2015 App

Download the app by searching for "IPM Symposium 2015."

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 Regional IPM Centers 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.

Poster Sessions

Two poster sessions will be held Tuesday, March 24 and Wednesday, March 25, 5:30–7:00 PM, in Hall 1 on the ground level of the Salt Palace Convention Center. While all posters will be displayed throughout the symposium, authors are asked to be by their posters according to their final poster number: odd numbers on Tuesday and even numbers on Wednesday.

Posters can be set up beginning at 9:30 AM on Tuesday. They should be in place by 5:00 PM on Tuesday. They can be removed after the Wednesday session is over at 7:00 PM. They must be removed by 3:00 PM on Thursday.

If you would like to have your poster posted on the 2015 IPM Symposium web site, copy your poster as a .pdf file and send to Elaine Wolff at wolff1@illinois.edu by May 15, 2015.

Poster Session Receptions

All registered participants and their registered guests are invited to attend the receptions, held during the poster sessions on Tuesday, March 24 and Wednesday, March 25 from 5:30–7:00 PM each night in Hall 1 on the ground level of the Salt Palace Convention Center. Hors d'oeuvres and a cash bar will be provided during the reception.

Silent Auction

The inaugural Silent Auction will be held Wednesday, March 25 from 5:30–7:00 PM. Visit us in Hall 1 at Booths 10 & 11, adjacent to the Poster Session, 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 create a new fund dedicated to registration and travel support.

Presenter Practice Room

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

Media

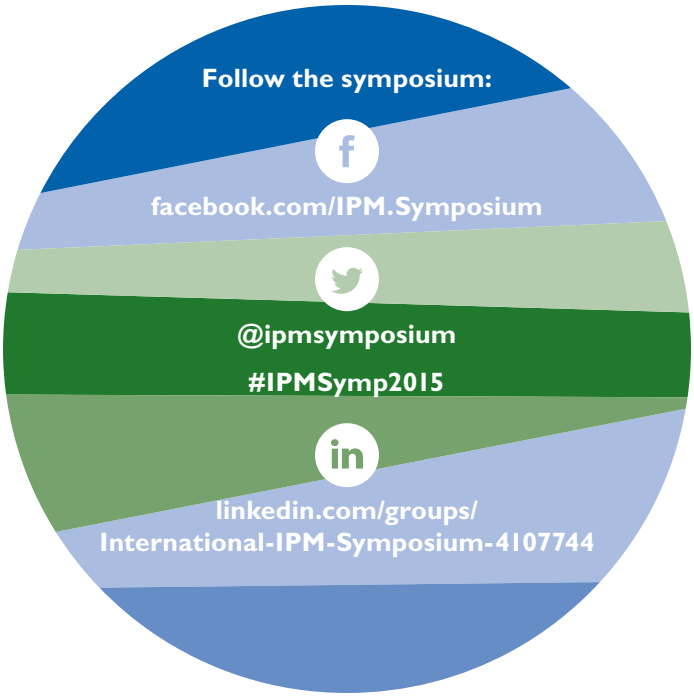
The Registration Desk will serve as the media desk, located in Hall I ground level of the Salt Palace Convention Center. Reporters and other members of the media should register at the Registration Desk.

Session Moderators

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

Continuing Education Credits

Sign-in sheets will be located in the sessions that qualify. Stop at the Registration Desk for more information.



Congratulations to the 2015 International IPM Achievement Award recipients

International IPM Awards of Excellence

Muck Crops IPM Program

Okanagan-Kootenay Sterile Insect Release (OKSIR) Program

International IPM Lifetime Achievement Award

Dr. George W. Norton

International IPM Awards of Recognition

Ms. Carrie Foss

StopBMSB Program

StopPests in Housing Program

These recipients will be recognized during the Awards Luncheon on Tuesday, March 24.

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: ipmcenters.org/ipmsymposium15/.

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

schedule at a glance

Monday, March 23

8:00–10:00 AM	National IPM Coordinator Meeting
10:00 AM–5:00 PM	Regional IPM Coordinator Meetings
12:00–5:00 PM	Registration Open
1:00–5:00 PM	Ag-Based Field Trip
1:00–5:00 PM	Community-Based Field Trip
1:00–5:00 PM	Gylling Data Management ARM Workshop
3:00–6:00 PM	Applications of Geo-Technologies in Agricultural IPM Decision Support
5:30–7:30 PM	Welcome Reception, Utah Museum of Contemporary Art

Tuesday, March 24

Beverages available in Hall 1 from 7:00 AM–5:00 PM

7:00 AM–5:00 PM	Registration Open
7:00–8:30 AM	Continental Breakfast
8:30–9:30 AM	Plenary Session—Dr. Parag Chitnis
9:45–10:45 AM	Concurrent Sessions
11:00 AM–12:00 PM	Concurrent Sessions
12:15–2:45 PM	Awards Luncheon and Speaker—Dr. Marc Lame
3:00–4:00 PM	Concurrent Sessions
4:15–5:15 PM	Concurrent Sessions
5:30–7:00 PM	Poster Session, Reception & Exhibits

Wednesday, March 25

Beverages available in Hall 1 from 7:00 AM–5:00 PM

7:30 AM–5:00 PM	Registration Open
7:00–8:30 AM	Continental Breakfast
8:30–9:30 AM	Plenary Session—Dr. David Shaw
9:45–10:45 AM	Concurrent Sessions
11:00 AM–12:00 PM	Concurrent Sessions
Lunch on own	
1:45–2:45 PM	Concurrent Sessions
3:00–4:00 PM	Concurrent Sessions
4:15–5:15 PM	Concurrent Sessions
5:30–7:00 PM	Poster Session, Reception & Exhibits
5:30–7:00 PM	Silent Auction

Thursday, March 26

Beverages available in Hall 1 from 7:00 AM–5:00 PM

7:30 AM–5:00 PM	Registration Open
7:00–8:30 AM	Continental Breakfast
8:30–9:30 AM	Plenary Session—Dr. Mark Robson
9:45–10:45 AM	Concurrent Sessions
11:00 AM–12:00 PM	Concurrent Sessions
Lunch on own	
1:45–2:45 PM	Concurrent Sessions
3:00–4:00 PM	Concurrent Sessions
4:15–5:15 PM	Plenary Session—Mr. Jim Jones

Friday, March 27

8:00 AM–12:00 PM	Evaluation and Assessment of IPM Programs

interest tracks

See Daily Schedule for times and locations

Session #	*Session Name*

Fruit, nut and specialty crops

1	Greenhouse IPM successes and integration of intensive biological control strategies in Canada and the US
9	Invasive species as drivers of dynamic IPM programs
14	IPM Working Group success stories
15	Integrated management of plant disease vectoring pests: Asian citrus psyllid, glassy-winged sharpshooter, *Bemesia tabaci,* flower thrips, and potato psyllid
23	Two invasive pests that fundamentally changed IPM in fruit and nut crops: Brown marmorated stink bug and spotted wing drosophila
31	Role of microbial control agents in IPM
37	The impact of pesticide exposure on indigenous cultural practitioners
40	eTools: Decision support for New York State growers
46	How a new working group used synergy to fuel economic impact and increase deliverables

Rangeland/natural and urban landscapes

2	Overcoming IPM challenges in the urban landscape: Implementation, establishment and evaluation
10	Increasing connections between IPM and wildlife damage management
16	Reaching new audiences: Innovative strategies to communicate IPM
24	IPM in a changing urban landscape: Sustainable farming in cities
32	New tools for your toolbox: Manipulation of agricultural and forest pests with Specialized Pheromone & Lure Application Technologies (SPLAT®)
38	Invasive plant management: An IPM approach
41	Protecting Mother Earth through tribal IPM and invasive species control: Preserving forests, foods, and traditional tribal cultural activities

Agronomic and row crops

3	IPM in arable cropping systems: Lessons learnt in European project
7	Issues surrounding adoption and resourcing of IPM
11	Kochia IWM: Tumbling across the Great Plains
17	IPM is critical to managing pest resistance in transgenic crop production systems
25	Application of entomopathogenic nematodes in IPM
33	Herbicide resistance, weeds and IPM: The human dimension of how the problem evolved and how to mitigate the issues
42	Agronomic and economic benefits of seed treatments: The IPM perspective

General agriculture

4 Advanced technology for precision IPM: Latest developments with examples from the field and legal considerations

18 Does collaboration make IPM work?—Stories from OECD countries, Europe and Canada

21 IPM research projects in the UK and the southern Caribbean

28 Educating IPM practitioners: Critical component for sustainable agricultural systems

34 Pollinator protection: The role of IPM

43 Reducing the threat posed by africanized honey bees to workers, wildlife, and IPM in agriculture

Urban, structural, and school

5 Building international professionalism: Credentialing options for the people and places that practice IPM in the built environment

12 Digital governance technologies to support IPM decision making

19 Getting more green in professional pest management—Even for bed bugs

22 Inside/outside: How building design and structure can hurt or help IPM efforts

26 Innovative bed bug management strategies

29 New advances in school IPM

30 IPM adoption in colleges and schools: A view of the process

35 Tools for successful IPM in schools and childcare centers: Collaborating resources for the National IPM Training Program and best management practices

39 Tools for successful IPM in schools and childcare centers: Measuring and evaluating verifiable school IPM

44 Tools for successful IPM in schools and childcare centers: Improving environmental health and literacy through school IPM partnerships

47 Smart, sensible and sustainable approach to implementing your school IPM program (working session)

Vegetable crops

6 Biopesticides: Solid partners in IPM fruit and vegetable production

8 Pest to plate: The impossible job of talking to eaters about IPM

13 IPM finds food safety

20 Socio-economics and opinion research as strategic tools for IPM: Values and drivers to enhance planning, adoption and tech transfer

27 Synergizing organic and IPM

36 IPM Innovation Lab's IPM components and packages for tropical agriculture

45 Can insecticide mixtures be used to better enable IPM?

daily schedule

Monday, March 23

8:00–10:00 AM	**National IPM Coordinator Meeting** | *155B*
10:00–3:00 PM	**SERA-003** | *155A*
10:00–5:00 PM	**WERA-1017** | *155C*
10:00–5:00 PM	**NEERA-1004** | *155D*
10:00–5:00 PM	**NCERA-222** | *155E*
1:00–5:00 PM	**Ag-Based Field Trip** | *meet at Registration Desk, Hall 1 at 12:45 PM*
1:00–5:00 PM	**Community-Based Field Trip** | *meet at Registration Desk, Hall 1 at 12:45 PM*
1:00–5:00 PM	**Gylling Data Management ARM Workshop: Improve Experiment Quality using ARM 2015** | *155F*
3:00–6:00 PM	**Optional Specialized Workshop—Applications of Geo-Technologies in Agricultural IPM Decision Support** | *155B*
5:30–7:30 PM	**Welcome Reception** | *Utah Museum of Contemporary Art, 20 S. West Temple St. (east side of Salt Palace)*

Tuesday, March 24

8:30–9:30 AM **Opening Plenary Session**

"Integrated Pest Management on a Hotter, Flatter, More Crowded Earth," Dr. Parag Chitnis, USDA's National Institute for Food and Agriculture | *355 BCEF*

9:45–10:45 AM **Concurrent Sessions**

1 Greenhouse IPM successes and integration of intensive biological control strategies in Canada and the US (part 1 of 2) | *155A*

2 Overcoming IPM challenges in the urban landscape: Implementation, establishment and evaluation (part 1 of 2) | *155B*

3 IPM in arable cropping systems: Lessons learnt in European project | *155C*

4 Advanced technology for precision IPM: Latest developments with examples from the field and legal considerations (part 1 of 4) | *155D*

5 Building international professionalism: Credentialing options for the people and places that practice IPM in the built environment (part 1 of 2) | *155E*

6 Biopesticides: Solid partners in IPM fruit and vegetable production | *155F*

11:00 AM–12:00 PM **Concurrent Sessions**

1 Greenhouse IPM successes and integration of intensive biological control strategies in Canada and the US (part 2 of 2) | *155A*

2 Overcoming IPM challenges in the urban landscape: Implementation, establishment and evaluation (part 2 of 2) | *155B*

7 Issues surrounding adoption and resourcing of IPM | *155C*

4 Advanced technology for precision IPM: Latest developments with examples from the field and legal considerations (part 2 of 4) | *155D*

5 Building international professionalism: Credentialing options for the people and places that practice IPM in the built environment (part 2 of 2) | *155E*

8 Pest to plate: The impossible job of talking to eaters about IPM | *155F*

12:15–2:45 PM **Awards Luncheon and Speaker**

"Developing leadership for IPM: expanding IPM excellence from scholars to policy entrepreneurs," Dr. Marc Lame, Indiana University | *355 BCEF*

3:00–4:00 PM **Concurrent Sessions**

9 Invasive species as drivers of dynamic IPM programs | *155A*

10 Increasing connections between IPM and wildlife damage management (part 1 of 2) | *155B*

11 Kochia IWM: Tumbling across the Great Plains (part 1 of 2) | *155C*

4 Advanced technology for precision IPM: Latest developments with examples from the field and legal considerations (part 3 of 4) | *155D*

12 Digital governance technologies to support IPM decision making (part 1 of 2) | *155E*

13 IPM finds food safety (part 1 of 2) | *155F*

4:15–5:15 PM **Concurrent Sessions**

14 IPM Working Group success stories | *155A*

10 Increasing connections between IPM and wildlife damage management (part 2 of 2) | *155B*

11 Kochia IWM: Tumbling across the Great Plains (part 2 of 2) | *155C*

4 Advanced technology for precision IPM: Latest developments with examples from the field and legal considerations (part 4 of 4) | *155D*

12 Digital governance technologies to support IPM decision making (part 2 of 2) | *155E*

13 IPM finds food safety (part 2 of 2) | *155F*

5:30–7:00 PM **Poster Session (odd numbers), Exhibits, Reception** | *Hall 1*

6:30–8:30 PM **Stop School Pest Meeting—Everyone is invited to discuss school IPM** | *155E*

Wednesday, March 25

8:30–9:30 AM **Plenary Session**

"Herbicide Resistance–A Wicked Problem," Dr. David Shaw, Mississippi State University | *355 BC*

9:45–10:45 AM **Concurrent Sessions**

15 Integrated management of plant disease vectoring pests: Asian citrus psyllid, glassy-winged sharpshooter, *Bemesia tabaci,* flower thrips, and potato psyllid (part 1 of 2) | *155A*

16 Reaching new audiences: Innovative strategies to communicate IPM (part 1 of 2) | *155B*

17 IPM is critical to managing pest resistance in transgenic crop production systems (part 1 of 2) | *155C*

18 Does collaboration make IPM work?—Stories from OECD countries, Europe and Canada | *155D*

19 Getting more green in professional pest management—Even for bed bugs | *155E*

20 Socio-economics and opinion research as strategic tools for IPM: Values and drivers to enhance planning, adoption and tech transfer (part 1 of 2) | *155F*

11:00 AM–12:00 PM **Concurrent Sessions**

15 Integrated management of plant disease vectoring pests: Asian citrus psyllid, glassy–winged sharpshooter, *Bemesia tabaci,* flower thrips, and potato psyllid (part 2 of 2) | *155A*

16 Reaching new audiences: Innovative strategies to communicate IPM (part 2 of 2) | *155B*

17 IPM is critical to managing pest resistance in transgenic crop production systems (part 2 of 2) | *155C*

21 IPM research projects in the UK and the southern Caribbean | *155D*

22 Inside/outside: How building design and structure can hurt or help IPM efforts | *155E*

20 Socio-economics and opinion research as strategic tools for IPM: Values and drivers to enhance planning, adoption and tech transfer (part 2 of 2) | *155F*

1:45–2:45 PM **Concurrent Sessions**

23 Two invasive pests that fundamentally changed IPM in fruit and nut crops: Brown marmorated stink bug and spotted wing drosophila (part 1 of 3) | *155A*

24 IPM in a changing urban landscape: Sustainable farming in cities (part 1 of 3) | *155B*

25 Application of entomopathogenic nematodes in IPM (part 1 of 3) | *155C*

26 Innovative bed bug management strategies | *155E*

3:00–4:00 PM **Concurrent Sessions**

23 Two invasive pests that fundamentally changed IPM in fruit and nut crops: Brown marmorated stink bug and spotted wing drosophila (part 2 of 3) | *155A*

24 IPM in a changing urban landscape: Sustainable farming in cities (part 2 of 3) | *155B*

25 Application of entomopathogenic nematodes in IPM (part 2 of 3) | *155C*

28 Educating IPM practitioners: Critical component for sustainable agricultural systems (part 1 of 2) | *155D*

29 New advances in school IPM | *155E*

27 Synergizing organic and IPM (part 1 of 2) | *155F*

4:15–5:15 PM **Concurrent Sessions**

23 Two invasive pests that fundamentally changed IPM in fruit and nut crops: Brown marmorated stink bug and spotted wing drosophila (part 3 of 3) | *155A*

24 IPM in a changing urban landscape: Sustainable farming in cities (part 3 of 3) | *155B*

25 Application of entomopathogenic nematodes in IPM (part 3 of 3) | *155C*

28 Educating IPM practitioners: Critical component for sustainable agricultural systems (part 2 of 2) | *155D*

30 IPM adoption in colleges and schools: A view of the process | *155E*

27 Synergizing organic and IPM (part 2 of 2) | *155F*

5:30–7:00 PM **Poster Session (even numbers), Exhibits, Reception** | *Hall I*

5:30–7:00 PM **Silent Auction** | *Hall I*

Thursday, March 26

8:30–9:30 AM **Plenary Session**

"Challenges and Opportunities for Pest Management in the Developing World," Dr. Mark Robson, Rutgers University | *355BC*

9:45–10:45 AM **Concurrent Sessions**

31 Role of microbial control agents in IPM | *155A*

32 New tools for your toolbox: Manipulation of agricultural and forest pests with Specialized Pheromone and Lure Application Technologies (SPLAT®) | *155B*

33 Herbicide resistance, weeds and IPM: The human dimension of how the problem evolved and how to mitigate the issues (part 1 of 2) | *155C*

34 Pollinator protection: The role of IPM (part 1 of 2) | *155D*

35 Tools for successful IPM in schools and childcare centers: Collaborating resources for the National IPM Training Program and best management practices | *155E*

36 IPM Innovation Lab's IPM components and packages for tropical agriculture (part 1 of 2) | *155F*

11:00 AM–12:00 PM **Concurrent Sessions**

37 The impact of pesticide exposure on indigenous cultural practitioners | *155A*

38 Invasive plant management: An IPM approach | *155B*

33 Herbicide resistance, weeds and IPM: The human dimension of how the problem evolved and how to mitigate the issues (part 2 of 2) | 155C

34 Pollinator protection: The role of IPM (part 2 of 2) | *155D*

39 Tools for successful IPM in schools and childcare centers: Measuring and evaluating verifiable school IPM | *155E*

36 IPM Innovation Lab's IPM components and packages for tropical agriculture (part 2 of 2) | *155F*

1:45–2:45 PM **Concurrent Sessions**

40 eTools: Decision support for New York State growers | *155A*

41 Protecting Mother Earth through tribal IPM and invasive species control: Preserving forests, foods, and traditional tribal cultural activities (part 1 of 2) | *155B*

42 Agronomic and economic benefits of seed treatments: The IPM perspective (part 1 of 2) | *155C*

43 Reducing the threat posed by africanized honey bees to workers, wildlife, and IPM in agriculture | *155D*

44 Tools for successful IPM in schools and childcare centers: Improving environmental health and literacy through school IPM partnerships | *155E*

45 Can insecticide mixtures be used to better enable IPM? (part 1 of 2) | *155F*

3:00–4:00 PM **Concurrent Sessions**

46 How a new working group used synergy to fuel economic impact and increase deliverables | *155A*

41 Protecting Mother Earth through tribal IPM and invasive species control: Preserving forests, foods, and traditional tribal cultural activities (part 2 of 2) | *155B*

42 Agronomic and economic benefits of seed treatments: The IPM perspective (part 2 of 2) | *155C*

47 Smart, sensible and sustainable approach to implementing your school IPM program (working session) | *155E*

45 Can insecticide mixtures be used to better enable IPM? (part 2 of 2) | *155F*

4:15–5:15 PM **Closing Plenary Session**

"Protecting Human Health and the Environment in a Changing World," Mr. Jim Jones, US Environmental Protection Agency | *355 BC*

Friday, March 27

8:00 AM–12:00 PM **Optional Professional Development Session—Evaluation and Assessment of IPM Programs** | *155E*

poster numbers and titles

P001 IPM in the 21st Century—Invasive pests, resistance, environmental/consumer constraints and demand

P002 Evolution and impacts of the NYS IPM Weekly Field Crops Pest Report into social media

P003 Communicating sustainable potato production—A North America potato industry collaboration

P004 North Dakota wheat IPM survey: Ten-year review

P005 Implementing IPM in autumn-sown wheat in New Zealand using a participatory approach

P006 Impact of integrative crop and livestock production on pest and beneficial arthropods

P007 Survey of bees and syrphid flies associated with flowering soybean in the midwestern United States

P008 Pesticide contaminants found in bee hives placed in agricultural and non-agricultural habitats

P009 A new fungicide, insecticide, nematicide combination for nematode management in cotton

P010 Potential of incorporating sugarcane host resistance in integrated nematode management

P011 Laboratory assay of entomopathogenic nematodes against wheat stem sawfly, *Cephus cinctus*

P012 Pulse crop disease management: The role of a new regional pulse crop diagnostic laboratory in Montana

P013 Not presented

P014 Influence of cultivar, fungicide, and weather on frogeye leaf spot disease and yield in soybean

P015 Effects of thiamine treatment to control PVY on potatoes

P016 Applied management options to enhance crop safety against verticillium wilt

P017 Maine potato IPM program: Past-present-future

P018 Management of fusarium wilt in upland cotton of the southeastern United States

P019 Chemical treatments and host resistance reduced white mold and enhanced yield of soybean in Ohio

P020 Survey of fungal diseases in commercial soybean fields in South Dakota

P021 Prevalence and virulence of downy mildew on sunflowers in North Dakota

P022 Evaluation of a novel fungicide compound for management of downy mildew on sunflower

P023 RT-qPCR: A reliable assay for routine detection of RNA viruses of cereals and grasses

P024 The Sunflower Pathology Working Group

P025 An integrated approach to managing slugs in no-till corn systems

P026 Mitigation of corn rootworm with Bt traits and SAI—An industry perspective for BMP development

P027 Insect resistance management by systemic insecticide border treatment and egg parasitoids

P028 Promising myco-herbicide from *Cochliobolus lunatus* for weed *(E. crus-galli)* management in rice

P029 Present status of weed and weed management in rice in Sri Lanka

P030 Present status of herbicide usage in Sri Lankan paddy cultivation

P031 New and refined IPM tactics and tools for rice water weevil management in California rice

P032 Zone management and cotton IPM: Site specific control of *Lygus lineolaris*

P033 Not presented

P034 Developing strategies to manage thrips in peanut in absence of aldicarb

P035 NOCTOVI: An effective food based attractant for lepidopteran pests

P036 Thrips management in Texas high plains cotton

P037 Integrated lygus management in Texas high plains cotton

P038 Host plant resistance as a tool to manage tarnished plant bug in cotton in Arkansas

P039 Reducing pest occurrence in cotton and soybean utilizing interseeding technology

P040 Managing the soil seedbank with dicamba in fields with glyphosate-resistant Palmer amaranth

P041 Resistance of *Ammannia arenaria* to bensulfuron-methyl and its fitness cost

P042 Value of deep tillage in managing Palmer amaranth in cotton, tobacco, and sweet potato in NC

P043 Winter canola in Oklahoma: Pest management challenges and solutions

P044 In-field assessment of fitness in mixed glyphosate-resistant and -sensitive Palmer amaranth

P045 Western Region IR-4: Protecting specialty crops, practicing IPM, promoting global trade

P046 Utah fruit and vegetable IPM program and impacts

P047 Outcomes of the Western Small Farm IPM Working Group: Constraints and prospects for IPM on small farms

P048 IPM of specialty crops and community gardens in north Florida

P049 Development of bilingual material to facilitate early detection and control of the azalea lace bug

P050 iBooks: A new extension publication platform

P051 MyIPM, a new smartphone app for strawberry and peach disease management

P052 Role of IR-4 Ornamental Horticulture Program in developing IPM tools for specialty crops

P053 IPM of Oriental Fruit Moth, *Grapholitha molesta* (Busck) in peach orchards in northern China

P054 Collecting baseline data to develop IPM strategies for hops in Ontario, Canada

P055 Impact of applications of copper containing pesticides on earthworm communities in viticulture

P056 Chemical ecology of spotted wing drosophila

P057 Managing a new threat to berry crops through local and regional cooperation

P058 Optimizing IPM programs for spotted wing drosophila in blueberries

P059 Integrated management of Asian citrus psyllid using organic insecticides and parasitoids

P060 Host choice behavior based on sex in *Diaphorina citri* (Hemiptera: Liviidae) on citrus varieties

P061 Attract-kill strategy for *D. citri* control: Selection of insecticides to apply in curry leaf

P062 Acaricidal activity of an annonin-based commercial biopesticide against citrus red mite

P063 Impact of imidacloprid and kaolin clay on whitefly, natural enemies, and honey bee visitation

P064 Relating shade level and altitude with occurrence of *Hypothenemus hampei* and parasitoids on coffee

P065 Use of Puffer® pheromone aerosol dispensers for mating disruption in orchards

P066 Prionus beetle mating disruption and lure evaluation in Utah sweet cherry orchards

P067 IPM and technology—Digital insect trap for monitoring lepidopteran pests in orchards

P068 Insect identification using laser and wing beat frequency

P069 Changes in soil moisture modulate the beneficial and harmful microbial populations in avocado crops

P070 Approximate mathematical model for predicting avocado wilt based on climatic variables

P071 Mitigation of climate variability in avocado crops

P072 Insights into the epidemiology of grapevine leafroll disease in cool-climate viticulture

P073 Control effect of velvet bean seed extract against root-knot nematode, *Meloidogyne* spp.

P074 IPM in the Whole Foods Market Responsibly Grown Rating System

P075 The Southern IPM Center's signature programs

P076 IPM Voice advocates for progressive IPM

P077 Using trade journals to promote IPM tools for managing weeds problematic to agriculture in Nevada

P078 Developing volunteer survey networks through interagency first detector training

P079 Feed the Future Innovation Lab for IPM: Ecological systems-based approach

P080 Documenting and measuring collaboration at the Regional IPM Centers

P081 The IPM eAcademy: Online presentations and webinars addressing important IPM-related issues

P082 The Southern Region IPM Center's 2015 Friends of IPM awards

P083 Integrated Pest Information Platform for Extension and Education (iPiPE): A new USDA CAP

P084 Mobile IPM: Crop management, pest identification and forecasting and monitoring in Canada

P085 Utilizing webinars to increase the adoption of integrated pest management

P086 Innovative programming resources to enhance IPM decisions

P087 Ontario CropIPM—Interactive online IPM training modules

P088 Contemporary tools for the IPM tool box: Multi-criteria decision making and mind mapping software

P089 Pesticide Risk Mitigation Engine (ipmprime.com): A user-friendly online tool for field-specific risk assessment and mitigation

P090 A proposed Center for Ecology, Evolution and Management of Pesticide Resistance

P091 Factors affecting pistachio growers' adoption of IPM practices in Kerman Province, Iran

P092 On not reinventing the wheel: The Northern Plains IPM Working Group

P093 Advancing IPM for Midwest apple production using the Pesticide Risk Mitigation Engine (ipmPRiME.com)

P094 Building IPM capacity in Missouri through train-the-trainer workshops and effective partnerships

P095 Using interactive activities to educate and prepare workers for the Oregon pesticide applicator exam

P096 Sysco Sustainable Agriculture/IPM program

P097 NYS dairy cattle IPM: Research and outreach addressing dairy industry needs

P098 Soil treatment with destabilized compost and solarization: An alternative to fumigants

P099 Food-Safe compounds to protect Southern dry cured hams from the ham mite, *Tyrophagus putrescentiae*

P100 Systemic deterrence of aphid probing by natural and altered terpenoids may hinder virus transmission

P101 Exploring insect-associated fungal flora in central mixed agriculture zone in Pakistan

P102 20+ years of successful area-wide control for codling moth using sterile insect technique

P103 Contribution of GM-crops to IPM and agroecology

P104 The role of soil moisture in biofumigation of potato cyst nematodes (*Globodera* spp.)

P105 Biopesticides: A focus at Agriculture and Agri-Food Canada's Pest Management Centre

P106 IPM for leek moth—Successful partnerships achieving the research to technology transfer continuum

P107 A web-based cover crop decision tool for integrated crop management in Eastern Canada

P108 Advances in integrated management of fusarium head blight through Canada's Pest Management Centre

P109 Management of the cabbage maggot in brassica vegetables using polyethylene insect netting

P110 Hybrid of *R. patientia* × *R. tianschanicus* (*Rumex* OK-2)—a new invasive weed in Central Europe

P111 Integrated Pest Management (IPM) in grain legumes in Asia

P112 Use of *Trichoderma asperellum* and *Glomus intraradices* as biocontrol agents against okra seedling

P113 NRCS & IPM Working Group: Grower incentives for IPM

P114 Environmental drivers of trait changes in *Photorhabdus* spp.

P115 Public Tick IPM Working Group

P116 Not presented

P117 Western Region Tribal IPM Work Group: Learning to maintain forest health to sustain tribal values

P118 The IR-4 Public Health Pesticides Inventory—A new tool for integrated vector management

P119 Extension outreach tools for invasive pests and diseases

P120 Caught with your plants down? Get an app for that at PurduePlantDoctor.com

P121 Nevada extension public survey supports targeted approach to IPM education

P122 Yearly distribution (2007-2014) of tamarisk beetle, a biocontrol agent

P123 Effects of parasitoid and floral diversity on parasitism of a sagebrush defoliating moth across a montane landscape

P124 Biological control options for invasive weeds in Nevada

P125 Temperature, moisture, and herbicide effects on germination of Dyer's woad seeds

P126 *Hypena opulenta:* The first biological control agent released for control of swallow-worts in North America

P127 Pine engraver beetles invade the Sonoran Desert

P128 A semiochemical-based tool for protecting pines from mortality attributed to bark beetles

P129 The integrated management of bark beetles in conifer forests

P130 First record of the velvet longhorn beetle (*Trichoferus campestris* Faldermann) from Utah

P131 How destructive is brown marmorated stink bug to herbaceous perennial plants

P132 Conducting 21 turfgrass IPM educational seminars in a single day

P133 High-level IPM at Cooperstown's Doubleday Field

P134 "Lawn Care: The Easiest Steps to An Attractive Environmental Asset" ibook resource

P135 Not presented

P136 Tracking billbugs to improve IPM in intermountain west turfgrass

P137 Development of the University of Alaska Fairbanks integrated invasive plant management plan

P138 Phone apps and websites as tools for pesticide reduction in yards and gardens

P139 Promoting and teaching IPM as smart gardening

P140 Not presented

P141 Developing a straightforward index to track pesticide impacts over time based on San Francisco's Hazard Tier system

P142 National Pesticide Information Center: 20 years of science-based conversations

P143 BugGuide as a model for crowdsourcing extension diagnostics

P144 Stored product beetles: How physical and biological factors affect residual efficacy of insecticides

P145 PRI pesticide product evaluator: A tool for IPM

P146 Wyoming IPM for healthy schools and other facilities

P147 Facilitating compliance with a new IPM regulation in Utah's schools

P148 Using stakeholder interviews for improved IPM adoption

P149 Stop School Pests: Standardized national school IPM training

P150 Promoting IPM in affordable housing: A partnership between academia and the community

P151 Quality of life impacts of bed bug (*Cimex lectularius* L.) infestations

P152 Tackling fire ants, after a student death, a case study for school IPM in TX

P153 Cases of 12-year residential home termite IPM in Alabama

P154 Efficacy of *Datura stramonium* extracts incorporated into soil samples on termites' mortality

P155 Larvicidal evaluation of *Hyptis suaveolens* as lead-agent for control of mosquito-borne microbes

P156 Great Lakes Vegetable Working Group addressing vegetable industry IPM priorities

P157 Addressing the IPM needs of part-time, diverse vegetable producers in Kentucky

P158 Development and implementation of fruiting-vegetable grafting technologies for field production systems in the US

P159 Management of soilborne pathogens of tomato and strawberry: Local solutions and global benefits

P160 Utilizing pest phenology to manage cabbage maggot in brassicas

P161 Development and impact of a pest alert system for potato growers in the Columbia Basin of Washington

P162 Companion and refuge plants to enhance control of insect pests in vegetables

P163 Evaluating pesticide effects on pollinators and disease efficacy in cucurbits

P164 Beneficial insects in sweet corn bordered by native perennial and pasture border rows

P165 Trap cropping: A simple and effective organic IPM approach to manage multiple pests in cucurbits

P166 Effect of organic fertilizers and PGPR on the population growth of *Aphis gossypii* in the cucumber greenhouse

P167 IPM of insect pests of vegetable crops in the Holland Marsh, Ontario

P168 Assessing the risk of spotted wing drosophila (SWD), *Drosophila suzukii*, infestation to tomatoes

P169 Ground dwelling insects in sweet corn bordered by native perennial and pasture border rows

P170 Measuring the impact of IPM activities on tomatoes in East Africa

P171 South American tomato moth (*Tuta absoluta* Meyr) in Ukraine

P172 Field evaluation of commercial tomato cultivars against ageratum yellow vein virus in Guam

P173 Basket of options for IPM of tomato virus diseases

P174 Antagonistic activity of rhizobacteria against bacterial wilt of tomato plants in the Caribbean

P175 Using loess sulfur mixture for management of powdery mildew diseases in organic farming in Korea

P176 Improving carrot insect monitoring methods in the Holland Marsh, Ontario

P177 Development of diseases on muck vegetable crops in the Holland Marsh, Ontario in 2014

P178 Control effect of coffee bark compost against soil borne disease in organic ginger in Korea

P179 Efficacy of plant inducers and biopesticides for management of downy mildew on basil

P180 Drivers of IPM for onion thrips and iris yellow spot virus in onion

plenary sessions

Tuesday, March 24

355 BDEF

8:30 **Welcome from the symposium committees,** Margaret Appleby, Co-Chair, Symposium Steering Committee, margaret.appleby@ontario.ca, Ontario Ministry of Agriculture, Food and Rural Affairs, Brighton, ON, Canada

Welcome to Utah, Clark Burgess, Deputy Director of Plant Industry and Conservation, Utah Department of Agriculture and Food

Introduction of Parag Chitnis, Norman C. Leppla, ncleppla@ufl.edu, Entomology and Nematology, University of Florida, Gainesville, FL

Integrated Pest Management on a hotter, flatter, more crowded earth, Parag Chitnis, parag.chitnis@nifa.usda.gov, USDA's National Institute of Food and Agriculture (NIFA), Washington, DC

The potential growth of the global population to nine billion people by 2050 presents some significant challenges that the population can only address by research and translating that research such that it can improve people's lives. Beginning right now, we will need to find ways to feed, clothe, and shelter all people without wreaking havoc on the environment. There are major biological, environmental, behavioral and policy implications for agriculture and science from a rising population. It will be critical to consider the biology of how we grow food. Looking at the dinner table worldwide, 50 percent of our harvest is lost pre-harvest in the developing world, and 50 percent is lost post-harvest in developed countries. From an IPM perspective, we need to look at new technologies, such as robotics, sensors, and synthetic biology, to detect, control and prevent pathogens and pests. However, we can't forget the basics of integrated pest management: monitoring and surveillance. These tried and true practices, combined with advancements in technology and their creative application to agriculture will help us provide safe, healthy and abundant food and meet the challenges surrounding a rapidly rising global population.

12:15 **International IPM Achievement Awards Luncheon**

Presiding, Janet Hurley, Janet Hurley, ja-hurley@tamu.edu, Texas A&M AgriLife Extension Service, Dallas, TX

Remarks, Todd Reese, Director of Salt Lake City Parks and Public Lands

Awards presentations

The International IPM Awards of Excellence will be given to:

Muck Crops IPM Program, Holland Marsh region of Ontario, Canada

Okanagan-Kootenay Sterile Insect Release (OKSIR) Program, British Columbia, Canada

The International IPM Lifetime Achievement in IPM Award will be given to:

Dr. George W. Norton, Virginia Tech University

The International IPM Awards of Recognition will be given to:

Ms. Carrie Foss, Puyallup Research and Extension Center, Washington State University (WSU)

StopBMSB Program

StopPests in Housing Program

Developing leadership for IPM: Expanding IPM excellence from scholars to policy entrepreneurs, Marc Lame, mlame@indiana.edu, School of Public and Environmental Affairs, Indiana University, Bloomington, IN

Integrated Pest Management is a well-established and proven innovation that evolved from the turbulence of the 1960s–the technical turbulence of Van den Bosch's "Pesticide Treadmill" and the social turbulence of the environmental movement. For those of us who started their careers in IPM in the early days we naively thought that the diffusion of IPM would occur because science was on our side. An early lesson for most of us was "Insects can be managed, but management is people oriented..." (Metcalf and Luckmann, 1975). In other words, "pest management is people management". We found that if we were going to succeed as Extension IPM Specialists we

would have to become "policy entrepreneurs" and lead the diffusion of IPM. Even as we move into the fifth decade diffusing IPM we cannot assume that this innovation will become sustainable for two reasons: Complacency and Political resistance. However, at this point we need new IPM specialists to take the reins of leadership. These new leaders must be enabled by current leadership to take risks. Rather than being distracted by defining what is IPM, they must demand detractors to define what is NOT IPM. They must develop core competencies beyond technical pest management for excellence in people management such as strategic planning, policy formulation, program evaluation, team development, and be able to ethically "co-produce" solutions resulting in well publicized, successful implementation.

Wednesday, March 25

355BC

8:30 Presiding, Jill Schroeder, Jill.schroeder@ars.usda.gov, United States Department of Agriculture Office of Pest Management Policy, Washington, DC

Announcement of 2016 International Congress of Entomology, Alvin Simmons, USDA-ARS

Herbicide resistance–A wicked problem, David Shaw, dshaw@research.msstate.edu, Mississippi State University, Mississippi State, MS

Incidences and severity of herbicide resistance are increasing globally, and pose serious risks unless bold moves to proactively manage the problem are taken. The spread of weed resistance is a natural ecological phenomenon due to the repeated use of herbicides with the same mechanism of action. Weed management professionals understand the causes of resistance and many of the management practices that can prevent it. Nevertheless, herbicide resistance is still increasing. Sustainable weed management is a classic example of what social scientists term a "wicked problem", one in which there is a highly complex set of interactions between natural and human systems that defy simple or straightforward solutions. Progress on this vexing problem demands a vigorous call to action. All parties to the problem must take ownership for finding innovative solutions, and move past the view that this is someone else's problem or fault. Simply continuing to do what was done in the past guarantees continued failure. Farmers must be viewed as collaborators with herbicide manufacturers, farm supply firms, federal and state government agencies, university scientists, crop consultants, and commodity and non-governmental organizations. Moreover, agricultural, biological and social scientists must engage with each other, and with the agricultural community, in broad interdisciplinary collaborations.

Thursday, March 26

355BC

8:30 Presiding, Lynn Braband, lab45@cornell.edu, New York State IPM Program, Cornell University, Rochester, NY

Challenges and opportunities for pest management in the developing world, Mark Gregory Robson, robson@aesop.rutgers.edu, School of Environmental and Biological Sciences, Rutgers University, New Brunswick, NJ

With the growing population in the world, currently at seven billion, the population will soon be nine billion. Governments, businesses, NGOs and farmers are developing strategies to increase food production and improve productivity and efficiency at the farm level. In some countries, notably those in SE Asia, governments have encouraged the importation and use of pesticides as a way to significantly increase crop production. Thailand, as an example, has become a major producer and exporter of rice. The increase in yield has been heavily dependent on a very large increase in the use of pesticides. In this presentation we will discuss the pattern of pesticide use, the benefits and risks associated with the increased use, and the health implications to farmers, farm families and rural communities. Case studies will be taken from SE Asia to demonstrate effective and ineffective protection strategies, exposure scenarios and training programs related to pesticide use.

4:15 Presiding, Dawn H. Gouge, dhgouge@email.arizona.edu, Department of Entomology, College of Agriculture and Life Science, University of Arizona, Maricopa, AZ

Protecting human health and the environment in a changing world, Jim Jones, Jones.jim@Epa.gov, Office of Chemical Safety and Pollution Prevention (OCSPP), U.S Environmental Protection Agency (USEPA), Washington, DC

EPA is supporting and promoting IPM in carrying out its mission to protect human health and the environment. IPM is a smart, sensible, and sustainable approach for managing pests where we live, work, plan, and farm. Our rapidly changing world presents many challenges managing pests and in providing the tools for their control. Our responsibility is to provide regulatory oversight of the pesticidal tools and concurrently advocate for the increased use of IPM and reduced risk alternatives, such as biopesticides, within IPM systems. EPA's IPM-related efforts are actively addressing the challenges of a changing world. Our School IPM program is making school environments healthier by reducing children's exposure to pests and pesticides. We are actively seeking IPM solutions to solve the corn rootworm resistance problem. Our biopesticide regulatory program is making it easier for these products, which are valuable in IPM systems, to reach the marketplace. EPA's multi-faceted pollinator protection efforts include IPM as a means of preventing harm to pollinators and their habitat. Design for the Environment is helping consumers and institutional buyers identify safer products, including pesticides. Together our programs are responsive to our Congressional mandate to promote IPM and to our public health and environmental protection charge.

5:10 **Closing remarks,** Norman C. Leppla, ncleppla@ufl.edu, Entomology and Nematology, University of Florida, Gainesville, FL

concurrent sessions

1 • Greenhouse IPM successes and integration of intensive biological control strategies in Canada and the US

Room 155A

The challenges and successes surrounding greenhouse grower adoption of new IPM techniques in greenhouse production will be discussed. The session will be led by innovators in greenhouse IPM Extension and experts in utilizing biological control. The panelists represent locations in Canada and the Northeastern United States. We'll look what it takes to help growers implement IPM in ornamental and vegetable production greenhouses. A focus of the session will be on the adoption of biological control for arthopod managment.

Organizers: Kwesi Ampong-Nyarko, kwesi.ampong-nyarko@gov.ab.ca, Edmonton Special Crops, Alberta Ag and Rural Development, Edmonton, AB, Canada; Brian C. Eshenaur, bce1@cornell.edu, IPM Program, Cornell University, Ithaca, NY

9:45 1.1 Introduction, Brian C. Eshenaur

9:50 1.2 Development and implementation of IPM in Alberta greenhouses, Kwesi Ampong-Nyarko, kwesi.ampong-nyarko@gov.ab.ca, Edmonton Special Crops, Alberta Ag and Rural Development, Edmonton, AB, Canada

The Alberta greenhouse industry is estimated to be 127ha. It employs over 1,600 full-time and over 3,200 part-time with annual sales of $162 million. Pest management in greenhouses is an on-going production constraint for growers. A three-year project is encouraging grower adoption of IPM and evaluating nonchemical control strategies to improve growers competitiveness.

10:15 1.3 IPM in Canadian greenhouse floriculture: Making it work, Michael Brownbridge, michael.brownbridge@vinelandresearch.com, Horticultural Production Systems, Vineland Research & Innovation Centre, Vineland Station, ON, Canada

At first glance, greenhouse crop production systems appear to be relatively simple. But at any given time, there are multiple interactive variables which can affect a pest management strategy. To add to the complexity, greenhouse floriculture relies on the production of an aesthetically perfect crop for retail sale. To develop resilient IPM programs we need to capitalize on contributions from several different components and ensure they function efficiently together, particularly when biocontrol agents are used. This presentation will focus on factors driving change in Canadian floriculture and highlight biologically-based IPM programs that are being successfully implemented on a commercial scale.

11:00 1.4 Something old, something new—Encouraging greenhouse growers to use IPM, Elizabeth Lamb, NYS IPM, Cornell University, Ithaca, NY; Brian Eshenaur, NYS IPM; John Sanderson, Cornell University; Neil Mattson, Cornell University

Asking growers to add one more thing to their production system can be a challenge. We've used a variety of methods to encourage ornamental and vegetable greenhouse growers in NYS to improve their use of IPM - some 'old' and some 'new'. I'll use biocontrol as an example to discuss what we have tried and how well it has worked.

11:25 1.5 Transitioning to biocontrols one grower at a time, Ronald Valentin, Ronald.Valentin@syngenta.com, Syngenta Flowers, Home and Garden, Gilroy, CA

Growers are having success changing to biological control of arthorpod pests. However the transition can be rocky if greenhouse managers don't consider the whole system. This session will review what it takes to support growers that are making the change to bio-controls.

11:50 1.6 Discussion

2 • Overcoming IPM challenges in the urban landscape: Implementation, establishment and evaluation

Room 155B

Pest management in the landscape continues to challenge us and in particular the implementation, establishment and evaluation of IPM. There is clearly a critical need for IPM practices in the landscape because it is here where new pests are often first established and build to high populations; there is often overuse or misuse of pesticides, there is a general lack of pest management information, tools and training for landscape problems; and there is an emotional relationship between people and their landscapes. These challenges continue to

increase with the onslaught of invasive pests, the critical need to reduce pesticide and other inputs into the environment, and the rising costs of management and maintenance of our landscapes. Research in overcoming impediments to wider adoption of sustainable landscape practices and technologies has led to a more comprehensive understanding of the role of environmental factors. Frequent education efforts directed at homeowners and industry has generated better-informed consumers. Societal pressure will continue to move towards sustainability and long-term, biologically based management. The purpose of this program is to bring together experts in research, extension and the industry to identify, discuss and prioritize challenges in implementing, establishing and evaluating IPM in the landscape and to identify where we can work together locally, regionally, nationally and globally to make IPM the norm for our landscapes.

Organizer: Catharine Mannion, cmannion@ufl.edu, Tropical Research and Education Center, University of Florida, Homestead, FL

9:45 2.1 Sustainable strategies: Conservation gardens in the urban landscape, S. Kristine Braman, kbraman@uga.edu, Depart of Entomology and Center of Urban Agriculture, University of Georgia, Griffin, GA; Bethany Harris

Habitat management to provide ecosystem services can be practiced at the individual, municipal and commercial landscape level. Plant selection at the local level to optimize conservation of pollinators and other beneficial insects can be facilitated by timely development and delivery of information concerning characterization of locally available landscape plant choices. Overcoming negativistic attitudes towards insects through education can also enhance adoption of sustainable strategies.

10:05 2.2 Invasive pests and the subtropic landscape—Is management possible?, Catharine Mannion, cmannion@ufl.edu, Tropical Research and Education Center, University of Florida, Homestead, FL

Managing invasive pests is an ongoing and worldwide problem and the subtropical environment provides an unusually conducive place for pest establishment. This is particularly evident in places like south Florida which continuously battles new pests in the landscape. Examples of invasive pests such as whiteflies and scales and their management will be discussed.

10:25 2.3 Meeting the challenge of managing plant disease in the subtropical urban landscape, Aaron Palmateer, ajp@ufl.edu, Tropical Research and Education Center, University of Florida, Homestead, FL

A subtropical climate provides favorable temperatures for year round pressure from numerous pathogens and often requires an integrated approach for successful disease management. This presentation will address some of the more common and newly emerging diseases affecting south Florida landscapes. Rust, mildews, canker and dieback diseases will be addressed including results from recent fungicide efficacy and nutritional amendment trials. Emphasis will be placed on novel disease management practices that are sustainable and environmentally sound.

11:00 2.4 Overcoming practical impediments to sustainability in the urban landscape, Svoboda V. Pennisi, bpennisi@uga.edu, Department of Horticulture, University of Georgia, Griffin, GA

The wider adoption of biodegradable containers for landscape use experiences various impediments related to plant establishment and container longevity under field conditions. Research has provided information on the impact of environmental factors on degradation of plantable biodegradable containers in native soils. Further studies should include practical guidelines for cultural modifications to maximize alternative container use in the landscape.

11:20 2.5 Optimizing plant breeding for sustainable landscapes, Carol Robacker, croback@uga.edu, Horticulture, Department of Horticulture, University of Georgia, Griffin, GA

Breeding for sustainable landscapes is an integral part of an IPM program. Incorporation of a variety of plant materials that are adapted to the urban landscape with qualities such as pest resistance and drought tolerance is essential. Native plants need to be part of the plant palette to support biodiversity. It is especially important to breed cultivars of native plants that can be produced commercially and grow well in landscapes. Sterile cultivars of non-native plants are also needed. Breeding of native azalea, little bluestem and Indian pinks, as well as non-native chaste tree, abelia and pearl bush will be discussed.

11:40 2.6 Can we successfully manage the landscape?

3 • IPM in arable cropping systems: Lessons learnt in European project

Room 155C

IPM historically developed in the area of insect pest control and primarily in high value crops such as orchards, vineyards and horticultural crops. Now IPM applies to all types of pests and since 1 January 2014 all professional users of pesticides in the EU are supposed to adhere to the 8 principles of IPM laid out in EU Directive 2009/128/EC. The objective of the EU project PURE (Pesticide Use-and-risk Reduction in European farming systems with Integrated Pest Management, 2011-15) is to provide practical IPM solutions to reduce the dependence on pesticides in major European cropping systems, including arable cropping systems based on either winter wheat (typical for northern Europe) or maize (typical for central-southern Europe), i.e. low value commodity crops. Cereal and maize based cropping systems have so far been neglected in an IPM

context, but with the EU Directive now in force the situation needs to change. For both cropping systems we compared two levels of IPM implementation to the current practice in 4 countries in on-station as well as on-farm experiments. In the first two presentations we will outline the configuration of the IPM systems highlighting the IPM tools put in use and compare the performance of the IPM systems with the current system in terms of pest control and yield. In the final presentation the results of the overall performance of the three systems in terms of economic and environmental performance will be presented.

Organizers: Per Kudsk, per.kudsk@agro.au.dk, Agroecology, Aarhus University, Slagelse, Denmark; Maurizio Sattin, maurizio.sattin@ibaf.cnr.it, Instituto di Biologia Agroambientale e Forestale, CNR, Legnaro, Italy

9:45 3.1 Introduction, Per Kudsk and Maurizio Sattin

9:50 3.2 Agronomic evaluation of IPM strategies in European winter-wheat production, Per Kudsk, per.kudsk@agro.au.dk, Agroecology, Aarhus University, Slagelse, Denmark; Caroline Colnenne-David; Silke Dachbrodt-Saaydeh; Roman Kierzek; Bo Melander; Adrien Newton; Lise Nistrup Jørgensen; Clotilde Toque

Within the European Project PURE, six three-year on-station experiments were conducted in five European countries to evaluate two IPM strategies (IPM1 and IPM2) against current practice (CUR). Overall weeds, diseases and pests were effectively controlled with CUR and IPM1 while unsatisfactory control was observed with IPM2 in some years and at some locations. IPM1 winter wheat yields were comparable to or in some cases lower than with CUR while yields with IPM2 was generally lower. Pesticide use was significantly reduced at both IPM1 and IPM2 compared to CUR. Several IPM tools were very effective and could, if implemented more widely, reduce the reliance on pesticides.

10:05 3.3 Agronomic evaluation of IPM strategies in European maize production, Maurizio Sattin, maurizio.sattin@ibaf.cnr.it, Instituto di Biologia Agroambientale e Forestale, CNR, Legnaro, Italy; Gregor Urek; Robert Leskovšek; Jaka Razinger; Lorenzo Furlan; Arnd Verschwele; Imre J. Holb; Marion Giraud; Florence Leprince; Nathalie Verjux; Gilles Espagnol; Vasileios P. Vasileiadis

Within the European Project PURE, on-farm trials were set up in five European countries to evaluate IPM tools against weeds and the European corn borer (ECB) in grain maize, compared to the conventional management (CON). On-station experiments were also conducted in three countries to evaluate two IPM levels against the CON in maize-based rotations. Overall, IPM tools tested on-farm provided sufficient weed control, without differences in ECB plant damage and maize yields compared to CON, whereas in on-station experiments IPM1 and CON performed similarly. Weed infestation and yield in IPM2 were higher and lower than in CON, respectively.

10:20 3.4 Economic and environmental evaluation of IPM strategies in wheat- and maize-based rotations, Vasileios Vasileiadis, vasileios.vasileiadis@ibaf.cnr.it, Instituto di Biologia Agroambientale e Forestale, CNR, Legnaro, Italy; Wim van Dijk; Lorenzo Furlan; Imre J. Holb; Florence Leprince; Maurizio Sattin; Silke Dachbrodt-Saaydeh; Per Kudsk; Maud Benezit;Caroline Colnenne-David; Roman Kierzek; Marianne Lefebvre; Adrian Newton; Clotilde Toque

Within the European Project PURE, long-term on-station experiments were conducted to evaluate wheat- and maize-based rotations with different IPM level against the conventional cropping system. IPM strategies aimed at reduction in or sustainable use of pesticides (e.g. band application of herbicides, mechanical weeding, bio-insecticides). The ex-post assessment of their sustainability was conducted using an adapted version of the DEXiPM model and overall, IPM systems were found to have lower environmental impact, whereas their economic sustainability depended on changes in costs of IPM tools, possible yield reductions and type of crops in the rotation compared to conventional systems.

10:35 3.5 Discusssion

4• Advanced technology for precision IPM: Latest developments with examples from the field and legal considerations

Room 155D

Technology is rapidly advancing in all areas of society, including agriculture. Across all types of production systems (e.g., organic, conventional) there is a need to apply technology beyond our current approach to improve the efficiency and economics of management. Pests are synonymous with crop production and are often ranked as the number one management cost. Now, public demand for a sustainably grown product has created economic incentives for producers to improve their practices stimulating greater interest in precision pest management. An opportunity exists numerous disciplines (e.g., engineering, agronomy, ecology, computer science) to pool their knowledge and work together to 'fill the gap' in high tech management of pests in crops. Never before has there been such pressure to produce more with less in order to sustain our economies and environments. For this symposium, we will focus on engineering developments and applications in the field with consideration for the legal aspects. Experts working in the engineering and computer programming fields along with pest management specialists and representatives

from regulatory will highlight this symposium that will include a panel discussion at the end.

Organizers: Jeff Bradshaw, jbradshaw2@unl.edu, Dept of Entomology, University of Nebraska, Scottsbluff, NE; Ian MacRae, imacrae@umn.edu, Dept of Entomology, University of Minnesota, Crookston, MN; Steve Young, sly27@cornell.edu, Northeastern IPM Center, Cornell University, Ithaca, NY

9:45 4.1 Robotics and sensors—Engineering developments, Ken Giles, dkgiles@ucdavis.edu, Department of Biological and Agricultural Engineering, University of California-Davis, Davis, CA

Small, unmanned aircraft systems (UAS) provide an opportunity for pesticide spray application in which the applicator can be displaced from close proximity of the spray discharge and in which the spray application can be made with highly targeted spatial resolution, particularly in challenging geographic terrain. In this project, a commercially manufactured UAS-mounted spray system was deployed in high-value specialty crops in California. The UAS used in this project was a unmanned aerial vehicle (UAV) and an associated ground control station that provided a means for remote control of the aircraft. The aircraft was a gasoline-powered helicopter (RMAX, Yamaha Motor Co., US, Cypress, CA, US) originally developed for spraying of rice fields in Asia. In this test, the primary experimental areas for spray deposition and performance assessment included a 0.6 ha block of Cabernet Sauvignon wine grapes located at the University of California Oakville Field Station in Napa County, CA US. The block consisted of 42 rows, each 61 m long with a row spacing of 2.4 m. Depending on the spray method deployed, specifically, the swath width used and the flight pattern flown, the UAS spray application could achieve 2.0 to 4.5 ha/hr work rates while applying volume rates of 14.0 to 39.0 L/ha. Spray deposition on the grape foliage increased with applied volume rate. In comparisons to ground-based sprays at 935 L/hr, deposition in the grape canopy from the UAS at 47 L/ha was similar.

10:15 4.2 Robotics and sensors—Examples from the field, Yong-Lak Park, YoPark@mail.wvu.edu, Plant & Soil Sciences, West Virginia University, Morgantown, WV

US agriculture and forest faces a major threat by many pests (e.g. insects, weeds, and plant diseases) distributed over large geographic areas. Specifically, noxious invasive species have caused considerable economic loss and environmental damage to agriculture and forests in the United States. The result of damage and loss caused by such pests is sometimes irreversible without accurate management of the threat in a timely manner. There have been few systems to efficiently detect, mitigate, and manage pests over large areas although airplanes with on-board pilots often are used to survey damaged areas and to deliver pesticides. However, the nature of the current manned-airplane approach carries with it an inherent risk for crashes, potentially resulting in loss of property or life. Thus, the safety of the aerial survey becomes the most important issue in such aerial deployments. In addition, technology fees (i.e. cost for using technology) is another factor that has a significant influence on the economics and efficiency of pest management over large areas such as forests and large agricultural production areas. During the last six years, my project team including aerospace engineers, pest management specialists, and ecologists conducted proof-of-concept studies and field experiments to develop technology available to a level where it could be adopted as a tool in pest detection, sampling, and management. In this presentation, I will talk about system development for safe, real-time, and economical detection and delivery of control measures against major pests using aerospace engineering and geospatial technologies. Target pests and natural enemies in this presentation include mile-a-minute weed and its insect natural enemy, morning glory, Pierce's disease, and spined solider bug.

11:00 4.3 Aerial imaging and remote sensing for precision agriculture and environmental stewardship, Abhijit Nagchaudhuri, anagchaudhuri@umes.edu, Engineering, University of Maryland Eastern Shore, Princess Anne, MD

ETM (Enhanced Thematic Mapper), MRI (Magnetic Resonance Imaging), and RADAR (Radio Detection and Ranging) are all familiar acronyms but they also have something else in common, they are all examples of devices for remote sensing—an expansive field encompassing approaches to extract information about objects without coming into physical contact with them. Remote sensing is extensively utilized by scientists and engineers in space and earth sciences, medical sciences, agriculture, various applications in the industry, defense, security, and social sciences. Remote sensing may be broadly classified as passive, where the sensing system acquires information from the solar reflectance or electromagnetic emission from objects (e.g., ETM) and active, where the sensing system provides its own source of directed radiation and captures reflectance or backscattering of the radiation from the target objects (e.g., RADAR). Support from federal agencies such as National Aeronautics and Space Administration (NASA) and National Institute of Food and Agricultures (NIFA/USDA) have allowed the development of a multidisciplinary team effort led by me in the broad areas of precision agriculture, remote sensing, and mobile robot based sensing platforms at University of Maryland Eastern Shore (UMES). In this presentation I will outline how my prior engagement in robotics and image processing attracted me to get involved in remote sensing in the land grant setting of UMES and elaborate on various active and passive sensors that we have used on variety of platforms including hand held devices, tethered blimps, kites, remote controlled model airplanes, manned airplanes, and agricultural sprayers with emphases on applications related to environmental monitoring and precision agriculture.

11:30 4.4 Remote sensing to proximal sensing: Applications in precision agriculture, Raj Khosla, Raj.Khosla@ColoState.edu, Soil and Crop Sciences, Colorado State University, Fort Collins, CO

Application of remote-sensing in production agriculture has been around for decades and is primarily based on reflectance of the sun's visible and near infrared light by soils or crops. It does not require contact between the sensor and the soil or crop, and is usually achieved using cameras mounted on satellites, airplanes, towers or unmanned aerial vehicles. In precision agricultural management systems it is of immense importance to accurately characterize and account for variability in soil properties and crop characteristics; biotic and abiotic stresses to optimize application of inputs for maximizing output or grain yield. Although use of remote sensing in production agriculture is promising, there are drawbacks including: cost, weather, timing, and remote sensing imagery often requires sophisticated computer programs and skilled labor to interpret and prepare the image for use. Proximal sensing differs from the traditional definition of remote sensing in that proximal sensing involves sensors placed on ground vehicles rather than aerial platforms and in most cases have their own source of energy. Using an active remote sensor (i.e. a sensor that has its own source of light energy) that can be mounted on a fertilizer application boom and/or tractor is an attractive alternative to the traditional aerial/satellite based remote sensing. There are a suite of 'active sensors' that are commercially available and are being employed in production agriculture to make better management decisions. This presentation will discuss (i) advances and applications of remote-sensing in quantifying spatial variability in soil properties to delineate site-specific management zones for precision management of crop inputs; and (ii) recent advances in application of proximal crop sensors for quantifying early detection of biotic and abiotic stresses in crop canopies for precision crop management.

3:00 4.5 Application of unmanned aerial systems for pest management: Opportunities and challenges, Manoj Karkee, manoj.karkee@wsu.edu, Biological Systems Engineering Department, Washington State University, Prosser, WA

Unmanned Aerial Systems (UASs), in general, consist of an aerial vehicle (unmanned), a ground support unit, navigation, guidance and control software for auto-pilot, and data and command communication systems. Aerial vehicles include both fixed wing planes and multi-copters ranging in size from insect-size platforms to missile carriers used in defense industry. Other components are generally proportionally sized to the vehicle. Among these, micro- to small-size systems are generally cost effective, and highly maneuverable and programmable, making them attractive for agricultural applications. Because of these features, UASs (also known as UAVs or Drones) have been playing an increasingly important role in production agriculture across the country and around the world. Particularly, the technology has shown promising applications in effective and efficient pest stress detection, monitoring and control. For example, a significant proportion of chemical application in rice production in Japan is carried out by UASs. Research, development and/or application of UASs are widespread in other part of Asia too including China, Thailand, and Malaysia, as well as in other continents including Europe and South America. In the United States, research and development activities has been ongoing for more than two decades with applications ranging from chemical spraying in vineyards in California, sugarcane growth monitoring in Hawaii, citrus disease detection in Florida, to bird deterrence in berry crops in Washington. In this presentation, a range of research and development activities as well as some commercial applications of UAS for pest management will be discussed. The presentation will also identify some of the major challenges of the technology including data to knowledge conversion, flight endurance, and public safety and regulations. The presentation will be concluded with a brief discussion on potential future directions in research and development for the successful integration of UAS technologies in integrated pest management.

3:30 4.6 Regulatory issues: Local, regional, and national laws, Matt Hampton, Matthew.E.Hampton@oig.dot.gov, Office of Inspector General, US Department of Transportation, Washington, DC

The US Department of Transportation (DOT) Office of Inspector General (OIG) is dedicated to improving the economy and efficiency of DOT programs, including those of the Federal Aviation Administration (FAA). FAA is tasked with overseeing the safest air transportation system in the world, including integrating unmanned aircraft systems into the National Airspace System as mandated in the FAA Modernization and Reform Act of 2012. The DOT OIG will discuss the results of its June 2014 report on FAA's progress in meeting Congressional mandates, including the requirement to issue UAS regulations. The DOT OIG will also discuss the status of Agency efforts to implement OIG recommendations to enhance the effectiveness of the Agency's UAS integration efforts and the key issues going forward.

4:15 4.7 Regulations that are appropriate and necessary and those that are not, Greg McNeal, gregory.mcneal@pepperdine.edu, School of Law, Pepperdine University, Malibu, CA

As many different industries begin setting requirements for commercial applications of UAS, there is a growing concern about the FAA's approach to regulating the industry, and how those regulations will govern the diverse needs of this emerging market. In this session, Professor McNeal will draw on his expertise as a lawyer and expert on public policy to: Apply that knowledge to the different requirements of the emergent UAS industry; Draw from his experiences consulting with UAS start-ups and advising investors to provide insight to the early

adopters; Discuss converging legal, cultural, and technological issues that will determine the future of the UAS industry and its use across industries.

4:45 4.8 Panel discussion

5 • Building international professionalism: Credentialing options for the people and places that practice IPM in the built environment

Room 155E

Across many business sectors, a well-educated consumer is fast-becoming the norm in today's economy. From internet review sites to professional credentialing, as the public becomes more discriminating in their choices, service professionals are becoming increasingly aware of the need for market differentiation. And while the consumer's position is ultimately enhanced by this drive toward education and professionalism, the number and diversity of credentialing options can prove to be dizzying for everyone. Professional credentialing began to emerge as a business practice in the pest management industry in the 1970's with the development of the American Registry of Professional Entomologists (ARPE) program, which later was absorbed by the Entomological Society of America (ESA) and morphed into the Board Certified Entomologist (BCE) certification. Now, with the development of ESA's Associate Certified Entomologist (ACE) program for professionals and other program and building certifications from other organizations, including for-profit, non-profit, and government institutions, professionalism in pest management is approaching an apex. This session will focus on the primary certification and credentialing options for IPM in the built environment. Speakers from some of the key players in the certification conversation will discuss what drove the inception and formalization of their credentialing programs. The session will conclude with a panel discussion on the future of IPM certification with an opportunity for those who did not present to ask and answer questions.

Organizers: Chris J. Stelzig, cstelzig@entsoc.org, Director of Certification, Entomological Society of America, Annapolis, MD; AllisonTaisey, ataisey@pestworld.org, National Pest Management Association, Fairfax, VA

9:45 5.1 Introduction, Allison Taisey

9:50 5.2 BCE and ACE: Trusted credentialling for the individual, Chris J. Stelzig, cstelzig@entsoc.org, Entomological Society of America, Annapolis, MD

In many industries personal credentialing is considered the gold standard of achievement. Entomology is no exception. The BCE and ACE credentials offered by the Entomological Society of America are an important way that pest management professionals and others who work with insects can differentiate themselves from the competition. While earning the BCE does require an academic degree in entomology, the ACE program is designed for advanced learners without the background of higher education. This presentation will focus on the details of what each credential means, how they are earned, and what the credentials state about those who hold them.

10:05 5.3 Improving the industry's image With QualityPro, Allison Taisey, ataisey@pestworld.org, National Pest Management Association, Fairfax, VA

The public's perception of pest management is based, in large part, by the employees of pest management companies. The QualityPro Certification offered by the National Pest Management Association (NPMA) is the mark of excellence in pest management. Over the past ten years, QualityPro has helped companies establish and maintain their integrity through the highest standard in professionalism including health and safety checks, hiring practices, customer relations, employee training, and offering GreenPro service. This presentation will highlight the components and administration of QualityPro.

10:20 5.4 Looking under the hood at IPM performance at pest management service companies, schools, hospitals and other facilities, Thomas Green, ipmworks@ipmworks.org, IPM Institute of North America, Inc., Madison, WI

Green Shield Certified applies a performance-based approach to certifying structural pest management service providers and facilities. IPM professionals visit candidates and complete a top-to-bottom evaluation of performance. Candidates receive a detailed report with findings and recommendations, and are eligible for certification once they meet a set of required standards and achieve a minimum score by implementing optional, advanced practices. In this presentation, we'll review commonly identified strengths and opportunities for improvement. Green Shield Certified is a project of the non-profit IPM Institute of North America. IPM STAR is a sister program specifically for school systems.

11:00 5.5 Providing a level of comfort with an uncomfortable topic: BedBug Central's bedbugFREE network, Jeff White, jeff.white@bedbugcentral.com, BedBug Central, Lawrenceville, NJ

With bed bugs being virtually eradicated from the US for 50+ years, an entire generation of our society didn't have to deal with bed bugs nor knew anything about them. This fact is why so much of the public and pest control industry were caught off-guard by their resurgence. This void in information and treatment protocol created a "Wild West-like" atmosphere where bed bug sufferers were unsure what they were going to receive when hiring a pest control company to eliminate

their problem. The bedbugFREE network creates a sense of security for homeowners that they are going to receive a bed bug elimination service from a knowledgeable and progressive pest management firm. The implementation and upkeep of BedBug Central's bedbugFREE network will be discussed in this session.

11:15 5.6 IPM certification by state lead agencies: Benefits and regulatory obstacles, Tim Drake, tdrake@clemson.edu, Clemson University Department of Pesticide Regulation, Pendleton, SC

This presentation addresses the feasibility of IPM certification and licensing by states, and the benefits derived from having such a certification / license available to pesticide applicators. Also discussed are examples of efforts within states to adopt IPM programs and regulatory obstacles that may hinder the adoption of this category by states.

11:30 5.7 Panel discussion on IPM credentialing, Dave Hedman, davehedman@yahoo.com, Thermapure, Ventura, CA; Robert Nowierski, rnowierski@nifa.usda.gov, IPM3, USDA/NIFA, Washington, DC; Frank Ellis, Ellis.Frank@epa.gov, US EPA, Washington, DC; plus other speakers

Without labels on the applicator themselves, how is a pest management consumer to know if their service provider is a trained professional or a fly-by-night spray junkie? That is the niche served by the standards of professionalism developed by public and private groups, all of which exist to protect the public's collective interests of safety and pest-free environments. In addition to the programs addressed by the Symposia speakers, there exist a host of other credentialing options, from complementary (and competing) certifications to traditional academic degrees. Our discussion panel will address some of the other options for professional IPM credentialing.

6 • Biopesticides: Solid partners in IPM fruit and vegetable production

Room 155F

Biopesticides are well accepted in modern agriculture and are an important component of a sound Integrated Pest Management Program for fruit, vegetable, row crop, nursery and ornamental and greenhouse growers. This symposium, organized by members of the Biopesticides Industry Alliance (BPIA) will focus on integrated approaches to management of insect pests and diseases with both traditional chemical and biopesticide/biorational/biocontrol strategies. Biopesticides offer growers alternative modes of action, helping to limit resistance development. Biopesticides also offer residue free pest control, short re-entry intervals and most have limited or 0 hours pre-harvest intervals. Learn from industry development experts and researchers on how to include biological pesticides and biocontrol systems into integrated production practices. Presentations and discussion will include demonstration and educational opportunities for integration of biological approaches into university and extension programming. Included will be real world examples of the successful introduction of various biological pesticides into integrated approaches. Presentations will include a brief overview of the industry and some biopesticide/biorational materials available to growers. The BPIA is an alliance of discovery, research, development, manufacturing, material supply, and service companies. BPIA is dedicated to fostering adoption of biopesticide technology through increased awareness about their effectiveness and benefits to progressive pest management.

Organizer: Bill Stoneman, bstoneman@biopesticideindustryalliance.org, Biopesticide Industry Alliance, McFarland, WI

9:45 6.1 Introduction to BPIA and the role of biopesticides in IPM programs, Bill Stoneman

9:50 6.2 Smart use of biopesticides in greenhouse herb and vegetable IPM programs, Mathew Krause, mkrause@bioworksinc.com, BioWorks Inc., Victor, NY

With increasing market demand for sustainably grown herbs and fresh produce, growers are being driven to consider using biopesticides for managing diseases, pests and weeds. Since many effective biopesticides are now available, determining which products to use and how to use them effectively can be challenging to growers new to biopesticides. Basic evaluation strategies, cost-benefit concepts and other elements to consider when deciding on which products to use will be introduced in this presentation. In addition, factors important to getting the most out of biopesticides in conventional, sustainable and organic production systems will also be discussed.

10:03 6.3 Growing roots, shoots, and fruits—The increasing collection of biorational products for IPM, Craig A. Campbell, craig.campbell@valentbiosciences.com, Valent BioSciences Corporation, Libertyvillle, IL

Across the world, there is a growing interest in sustainable food production. This awareness about the importance of environmental stewardship shows that people are ready to be reacquainted with the plants, animals, and land that produce our food. The time is right to increase the adoption of biopesticides in all segments of agriculture. Showcasing the excellent research on IPM solutions based on biorational products to replace or complement conventional chemicals is one way to do this. Fruits and vegetables form the cornerstone of a healthy diet and we can do more to show the public how horticulture benefits society. It is important to remember that biopesticides may require special considerations in their development and commercial use. Product shelf life can be considerably shorter than with conventional pesticides. Product application timing is strongly linked to efficacy. Sometimes biopesticides cannot on their own provide complete control of pathogens or insects, but are highly effective when used

along with other products. Biopesticides in general, and particularly microbial products, have important nuances. First in the research phase, and later when they are used by growers (stored, prepared, tank-mixed, and applied). For example, a new biorational product formulation under development at Valent BioSciences has a strong odor that makes chemical trespassing of concern. Large and small agrochemical companies alike are racing to develop insecticides, disease control products, herbicides, and plant growth regulators to provide crop producers with new biorational IPM solutions.

10:16 6.4 Biopesticides—The product of innovation, Pam Marrone, pmarrone@marronebio.com, Marrone Bio Innovations, Davis, CA

Biopesticides represent approximately $2-3 billion of the $56 billion pesticide market. Growth of biopesticides is projected to outpace that of chemical pesticides, with compounded annual growth rates of more than 15%. With global population expected to increase to 9 billion by 2050, there is an increasing need to produce more food more sustainably. When incorporated into crop production and pest management programs, biopesticides offer the potential for higher crop yields and quality. Added benefits include chemical pesticide residue and resistance management, shorter field re-entry, biodegradability, and low risk to beneficials, including honeybees. For these reasons, large agrichemical companies have become involved in biopesticides largely through acquisitions and licensing deals. Recently, several companies have started microbial biopesticide discovery programs. Challenges to the adoption of biopesticides include inappropriate testing regimes without considering biopesticides' unique modes of action and lingering perceptions of cost and efficacy. This talk will provide some case studies of best use of biopesticides in integrated programs through understanding their novel modes of action.

10:29 6.5 What will it take for biologics to achieve greater impact in production agriculture?, Paul Walgenbach, paul.walgenbach@bayer.com, Bayer Cropscience Biologics, West Sacramento, CA

Biologics encompass a vast array of organisms and plant extracts deployed in both broad acre and horticultural crops. They represent a diversity of modes of action and applications including, but not limited to seed treatments, soil inoculants and foliar pesticides. Their increased use and current research efforts are impressive in both absolute and relative terms. However the employment of biologics in production agriculture has been dominated by their use in organic production. Their use in conventional agriculture, although growing, remains dwarfed by conventional chemistry. The niches they serve are often driven by such issues as restricted entry intervals, maximum residue levels and personal protection equipment. More recently the demand by consumers for more organic and sustainably grown food had lead producers to innovate, finding more applications for their use. The aforementioned issues will continue to foster growth, but will not lead to widespread, mainstream acceptance. Improved products and more competitive pricing is one obvious solution. Production practices, IPM, attitudes and product positioning will be discussed to promote thought for improved opportunities for growth.

7 • Issues surrounding adoption and resourcing of IPM

Room 155C

Technological changes and advancements have brought about significant changes in the resources for and directions of IPM programs. This symposium will explore some of the changes that are occurring and their implications on the development of the IPM programs of the future.

Organizers: Charles Allen, ctallen@ag.tamu.edu, Texas A&M AgriLife Research and Extension Center, San Angelo, TX; Paul A. Horne, paul@ipmtechnologies.com.au, IPM Technologies Pty Ltd, Hurstbridge, Victoria, Australia

11:00 7.1 The role of IPM in a crowded and hungry world—Trends in field crop IPM in the US, Charles Allen, ctallen@ag.tamu.edu, Texas A&M AgriLife Research and Extension Center, San Angelo, TX

This talk will begin with a discussion on current trends in IPM in the major field crops which provide the majority of the food and fiber supporting the earth's population. Current status of IPM and government investment in food and fiber production and protection will be discussed. The impact of increasing world demand for agricultural products during the next 35 years and the level of preparedness of agricultural systems and educational institutions to provide for the coming needs will be discussed.

11:30 7.2 Adoption of IPM, Paul A. Horne, paul@ipmtechnologies.com.au, IPM Technologies Pty Ltd, Hurstbridge, Victoria, Australia

Integrated Pest Management around the world is typically characterised by low rates of adoption and very long time periods before there is significant uptake of IPM strategies. This is despite significant government support for IPM in many countries. It seems that slow rates of adoption of IPM are accepted even if that is not what is desired. However, this does not need to be the standard, and this workshop is to describe how recent work with several industries that shows that this certainly does not need to be the norm. We hope to demonstrate how IPM adoption can be rapid and offers examples (case studies) from three different agricultural industries (both horticulture and broad-acre) in two countries. The three case studies from Australia and New Zealand presented are: (1) Strawberries in Victoria, Australia—100% adoption in 4 years (entire industry); (2) Arable crops—Victoria, Australia—2 projects—100% adoption over 3 years (all participants); (3) Arable crops—New Zealand—2 projects—100% adoption over 3 years (all participants). In addition to looking at rates

of adoption, the reduction in reliance on insecticide spraying is discussed. It is proposed that the approach described in this paper could be used as a model for almost any agricultural sector, anywhere in the world, where the aim is to introduce an IPM approach and to change the perception of IPM being poorly adopted.

8 • Pest to plate: The impossible job of talking to eaters about IPM

Room 155F

Are we attempting the impossible by trying to educate consumers about pest management at the same time we're selling them food? Pests, pesticides and eating aren't (usually) an appetizing combo. And everything about IPM, from the name all the way through definitions, practices, and results, defies usual communication strategies. It's not a sound byte, not a cookie cutter, not simple, and constantly evolving. And it involves things most people would rather not think about while eating--bugs, weeds, and more. Despite many talented communicators in the IPM world, our messages too often fail. There is progress: School IPM, StopPests.org, and Eco Apple are examples beginning to gain traction. The Know Your Farmer movement offers a new window: consumers want to know the story behind what they buy, and more and more are willing to accept complexity if they believe they're being told the truth.

The stakes could not be higher. If we hope to move agriculture, research, and public policy toward more sustainable, IPM-based approaches, we've got to get better at talking about what we do, and why it matters. Two veteran communicators in food marketing and IPM in the produce industry take this challenge back to basics. We'll look at current efforts, opportunities, challenges, core messages and the latest research on framing, to explore how we can position IPM-based approaches positively in the minds of the general public, and discuss strategies, ways to collaborate, and sharing resources.

Organizers: Susan Futrell, sfutrell@redtomato.org, and Michael Rozyne, mrozyne@redtomato.org, Red Tomato, Plainville, MA

11:00	8.1	Round table discussion, facilitated by Susan Futrell and Michael Rozyne

9 • Invasive species as drivers of dynamic IPM programs

Room 155A

With each new pest invasion we hear about the "death" of IPM. Is this doom and gloom scenario hysterical hyperbole? Or is this a real phenomenon? Saying IPM will die because of a new pest suggests that IPM practices are static or that we have reached the pinnacle of IPM with nowhere else to go from here. Most IPM practitioners know intuitively that IPM practices must be dynamic to deal with an ever-changing pest landscape. This is true for the pest populations that are perennial as well as new invasions—perennial pests go through ebbs and flows, as do our strategies for monitoring and managing them. Why then the constant death knell for IPM? Perhaps instead of saying "IPM is dead" every time a new pest comes along, we say "IPM must evolve". This mini-symposium will address these ideas using a case study format focused on particular invasions—how they were initially perceived (e.g. by the media, by growers, etc.) and how IPM programs evolved to meet these new challenges. Case studies will center on fruit production, specifically: brown marmorated stink bugs in mid-Atlantic orchards, Asian citrus psyllid and citrus greening in Florida orchards, and spotted wing drosophila in susceptible Michigan fruit crops. A brief discussion will be held at the end on how we might go about changing the language associated with new invasions and their impact on IPM program education and outreach.

Organizer: Julianna K Wilson, jkwilson@msu.edu, Entomology, Michigan State University, East Lansing, MI

3:00	9.1	Progress in IPM techniques for managing brown marmorated stink bug in mid-Atlantic orchards, Anne L. Nielsen, nielsen@AESOP.Rutgers.edu, Entomology, Rutgers University, Bridgeton, NJ
3:18	9.2	Battling the Asian citrus psyllid and citrus greening in Florida, Kirsten S. Pelz-Stelinski, pelzstelinski@ufl.edu, Entomology, University of Florida, Lake Alfred, FL
3:36	9.3	The recent invasion of the spotted wing drosophila and its effects on Michigan fruit production, Julianna K. Wilson, jkwilson@msu.edu, Entomology, Michigan State University, East Lansing, MI
3:54	9.4	Panel discussion

10 • Increasing connections between IPM and wildlife damage management

Room 155B

Managing damage by wild vertebrates, frequently referred to as wildlife, is often important in both agricultural and non-agricultural contexts, and wildlife damage management (WDM) has incorporated important tenets of IPM. However, the history of the development of the two disciplines has been largely separate, and there have been important differences in the approaches and emphases. We will briefly review the parallel histories of IPM and WDM and present examples of recent collaborations including the Internet Center of Wildlife Damage Management, interaction between eXtension's WDM and Urban IPM Communities of Practice, and the National Wildlife Control Training Curriculum. A round table discussion will follow on if the current level of interaction is satisfactory or is there a need for larger and more

consistent collaborations? If the latter, possible strategies will be developed.

Organizer: Lynn Braband, lab45@cornell.edu, New York State IPM Program, Cornell University, Rochester, NY

3:00 10.1 Parallel universes? Increasing connections between IPM and wildlife damage management, Lynn Braband, lab45@cornell.edu, New York State IPM Program, Cornell University, Rochester, NY

Managing damage by wild vertebrates, frequently referred to as wildlife, is often important, and wildlife damage management (WDM) has incorporated important tenets of IPM. However, largely separate academic backgrounds have nurtured the IPM and WDM communities. The controversial "hot button" topics have tended to differ. While WDM research and outreach have received some IPM funding and WDM studies occasionally appear in IPM journals, attendance at the rare WDM session at IPM meetings has been sparse. The objectives of this session are to review important examples of collaboration and to evaluate where we might go from here.

3:15 10.2 Thank goodness they got all the dragons: Wildlife damage management through the ages, Maureen G. Frank, maureen.frank@aggiemail.usu.edu, Wildland Resources Department, Utah State University, Logan, UT

Human use of natural resources has brought people and wildlife into contact for millennia. All too often, these encounters threaten human lives and livelihoods. Even though changes in technology have improved some aspects of wildlife damage management, many management tools, such as traps, scarecrows, and poisons, have changed little throughout human history. Human population needs, economic stability, and shifting social paradigms have a greater impact on human responses to wildlife damage. Understanding historic wildlife damage management can guide today's resource managers as they face new challenges such as overabundant game populations, invasive species, and urban wildlife.

3:35 10.3 How wildlife damage management interects with and is different from other IPM, Robert Schmidt, robert.schmidt@usu.edu, Environment & Society Department, Utah State University, Logan, UT

4:15 10.4 Recent collaborations: Internet Center for Wildlife Damage Management, National Wildlife Control Training Program & Master Gardener Training, Raj Smith, raj.smith@cornell.edu, Cornell University, Ithaca, NY; Stephen Vantassel, University of Nebraska; Paul D. Curtis, Cornell University

IPM programs for wildlife damage management (WDM) use animal behavior and ecology to reduce property damage or nuisance concerns. WDM and IPM principles are similar, and can be applied to both agricultural and suburban settings (i.e., homes, gardens, and workplaces). The Internet Center for Wildlife Damage Management is a non-profit, grant funded site that provides research-based information on how to responsibly handle wildlife damage problems. This presentation will trace the development of the website, including its connections with the broader IPM community. The Master Gardener Training curriculum discussed in this presentation covers examples of WDM using an IPM approach.

4:35 10.5 Wlidlife damage management in the digital age: Collaborating with others to spread the message, Fudd Graham, grahalc@auburn.edu, Auburn University, Auburn, AL; Janet Hurley, Texas AgriLife Extension; Kathy Flanders, Auburn University

This presentation will discuss how these 3 seemingly disparate groups came together to promote IPM and WDM by sharing information on websites and through webinars. Originally, each community of practice (CoP) on eXtension was set up to be a unique information source. It became clear very early in eXtension's development that many of these 'unique' sites had or needed information that could be used by others. These 3 CoP's had the foresight to work together and link information rather than creating new material.

4:55 10.6 Are current IPM/wildlife damage management connections sufficient?, Panel discussion

A round table discussion will follow on if the current level of interaction is satisfactory or is there a need for larger and more consistent collaborations? If the latter, possible strategies will be developed.

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11 • Kochia IWM: Tumbling across the Great Plains

Room 155C

Kochia [*Kochia scoparia* (L.) Schrad.] is an increasingly troublesome summer annual weed. Kochia has been reported in 42 of the lower 48 states and in the seven Canadian provinces neighboring the US border. Integrated weed management systems need to be designed and adopted for this weed species, mainly because of the prevalence of single and multiple herbicide-resistant biotypes of kochia that have been identified. Biotypes have been found resistant to ALS- and photosystem II inhibiting herbicides, synthetic auxins, and glyphosate. The glyphosate-resistant biotypes were recently confirmed in 2007 and now exist in many of the states and provinces in the central Great Plains. It threatens the progress of conservation tillage efforts in the Great Plains because kochia could be controlled with tillage but wind erosion is an issue. Collaborative research groups have gathered data on kochia seed biology and ecology, on its genetic and molecular characteristics, and on evaluating other herbicide products, alternative timings and means of weed control. Kochia thrives in drier climates and

behaves as a tumbleweed spreading its viable seed wherever it rolls. It is capable of producing up to 25,000 seed per plant, is competitive in field crops such as sugarbeet, sunflower, corn, soybean, wheat, canola, spring oats, and in fallow land. Collaborative research and extension efforts among university, government, and industry researchers in the Great Plains have generated a more comprehensive picture of this species in order to begin developing and implementing IWM strategies for its management.

Organizer: Anita Dille, dieleman@ksu.edu, Agronomy Department, Kansas State University, Manhattan, KS

3:00 11.1 Origin and status of kochia in North America, Phillip Stahlman, stahlman@ksu.edu, Agricultural Research Center-Hays, Kansas State University, Hays, KS

Kochia (*Kochia scoparia* L.) was introduced to North America from Eurasia in the early 1900's, reportedly for use in ornamental plantings. Kochia escaped into the landscape where it naturalized and thrived in semi-arid environments of the western United States and Canada. During droughts in the 1930's, it became widespread and currently is a major broadleaf weed in cropland and natural areas. This presentation will set the stage for following presentations.

3:20 11.2 Kochia occurrence in northern Great Plains and Canada, Linda Hall, lmhall@ualberta.ca, Agricultural Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada

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3:40 11.3 Kochia biology and ecology: Deciphering the weed adaptive process to guide IWM, Prashant Jha, pjha@montana.edu, Southern Agricultural Research Center, Montana State University, Huntley, MT; Anita Dille, Department of Agronomy, Kansas State University

There is a need to develop IPM decision-making to reduce inherent increased selection pressure for herbicide-resistant weed development. Our research suggests that kochia has a short-lived soil seed bank (1-2 yr), and burial through tillage could significantly reduce the seed bank recruitment of this small-seeded weed. Regional data on kochia population dynamics and life cycle (seed-to-plant-to-seed) changes under diverse environmental and management conditions would provide new insights into weed adaptive evolution. It will aid in developing proactive, evolutionary-based herbicide-resistance management practices that integrate both herbicides and non-chemical tools.

4:15 11.4 Physiological and molecular characterization of multiple herbicide resistance in kochia, Mithila Jugulam, mithila@ksu.edu, Agronomy Department, Kansas State University, Manhattan, KS; Todd Gaines, Bioagricultural Sciences and Pest Management, Colorado State University

Physiological and molecular mechanisms of multiple herbicide resistance (e.g. PSII-, ALS-, EPSPS-inhibitors and auxinic herbicides) in kochia populations from western Great Plains were investigated. Target gene mutations in psbA and ALS gene resulted in PSII-and ALS-inhibitor resistance in these populations. Glyphosate resistance in kochia was attributed to increase in EPSPS copies (5 to 16) and these copies were arranged in a tandem configuration. Preliminary research suggest that the evolution of dicamba resistance in kochia was not due to reduced uptake/translocation nor enhanced metabolism of dicamba. Understanding mechanisms of herbicide resistance in kochia is valuable for designing integrated weed management strategies.

4:30 11.5 Identifying herbicide control options for kochia, Andrew Kniss, akniss@uwyo.edu, Department of Plant Science, University of Wyoming, Laramie, WY; Curtis Thompson, Department of Agronomy, Kansas State University

Field studies were initiated in Kansas, Nebraska, Colorado, Wyoming, and South Dakota in 2010 and 2011. Three herbicide treatments were chosen for each of five major crops. The goal was to control kochia without the use of glyphosate. The trial was established in the absence of crop competition. Kochia control was estimated visually 3 to 4 weeks following the final herbicide application and weed biomass collected. Corn herbicide treatments reduced kochia biomass by 96%, while soybean, wheat, and fallow treatments reduced kochia biomass 80 to 85%, and sugarbeet treatments reduced kochia biomass by 32%.

4:45 11.6 Options for preplant control of kochia, Brian Jenks, brian.jenks@ndsu.edu, North Central Research Extension Center, North Dakota State University, Minot, ND

Field studies conducted near Minot, ND in 2013 and 2014 evaluated preplant or preemergence chemical control of glyphosate-resistant kochia. The focus was on soybean herbicide options in a no-tillage environment even though no crop was planted in the field. Kochia was 8 to 10 cm tall at time of treatment in June of 2013 and 2014. Visual kochia control was evaluated during the season. Herbicide mixtures with sulfentrazone generally provided excellent kochia burndown and residual control in this trial.

5:00 11.7 Kochia IWM: Discussion of our control options, Anita Dille, dieleman@ksu.edu, Agronomy Department, Kansas State University, Manhattan, KS

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12 • Digital governance technologies to support IPM decision making

Room 155E

Site specific information is critical to sound decision making in IPM. Without it, the complex pest issues in ever increasing global commerce and rapidly changing climate facing our world cannot be effectively and completely dealt with. The information includes a good quality geo-referenced data sets on pest presence/absence, relative abundance, prevalence, damage, habitat, environment etc. that can allow accurate spatial-temporal analysis important for proper and timely decision making to effectively plan and implement integrated pest management (IPM) program. The data can be used in planning (operations, strategic management, program development and direction), improving efficiency and effectiveness, improving management decisions, more strategic management, better time management, improved understanding of trends, record keeping, evaluation and succession planning.

Through three distinct projects (public agency, commercial structural IPM service provider, and pest mangement software developer), the proposed session will provide participants an outlook on development of IPM data management system (decision support tools). The presentations will offer participants an understanding of fundamentals and essentials of geo-referenced data, common elements of every IPM information system, standard attributes for IPM data, database designs, GIS applications in pest control, business and functional requirements for developing mobile geo-referenced pest monitoring apps and software, and costs involved in developing these tools. The adoption of these tools is a move away from primarily paper-based methods of pest traceability to consolidated digital methods that provide greater immediacy and accessibility of accurate spatial-temporal pest data for proactive IPM. In addition, the data can help advance IPM applications related to policy, research, training, and extension needs.

Organizer: Naresh Duggal, Naresh.Duggal@ceo.sccgov.org, IPM, Santa Clara County, San Jose, CA

3:00 12.1 Introduction: Need for digital governance in pest management, Naresh Duggal

3:10 12.2 Digital governance in structural IPM: System development and project automation—The Orkin approach, Zia Siddiqi, ZSiddiqi@rollins.com, Orkin, Atlanta, GA

Orkin employ nearly 8,000 team members in more than 400 locations in the North and South America, Europe, Africa, Asia, and Australia; providing pest control services to approximately 1.7 million customers. These services are backed by an exceptional quality assurance program, a team of experts, and comprehensive documentation based on data collected during services. Collecting and managing data at this scale requires digital governance. It has evolved over the last 15 years to meet varying needs of customers especially for IPM and food safety programs. It includes collecting data in field from bar-coded pest control devices, data-analytics with bi-directional interface with existing operating systems and on-line reporting. This presentation will review Orkin's journey in developing digital system, resources invested, and benefits.

4:15 12.3 Digital governance in structural IPM: System development and project automation—The County of Santa Clara approach, Naresh Duggal, Naresh.Duggal@ceo.sccgov.org, IPM, Santa Clara County, San Jose, CA

Site specific inspections and accurate problem identification are critical first steps prior to making any pest control application. This knowledge is important to the success of an IPM program. Besides pest biology, structural IPM professionals must understand how to develop a site survey and IPM plan, monitor pest populations and then assist customer in habitat modifications through improvements in structural and landscape designs, sanitation, housekeeping and maintenance. Since 2003, the County of Santa Clara IPM program started using digital governance tools such as PDA based software, bar code scanners and web based applications to conduct structural IPM inspections. The information collected is real-time and data analysis is designed to obtain the maximum amount of quality information using minimal amount of effort to track trends, predicting and countering potential problems before they can get serious pest issues.

4:45 12.4 Case studies on benefits of spatial technologies for pest and environment management and biosecurity, Sally Casey, scasey@iconyx.com, Iconyx Pty. Ltd., Bundoora, Victoria, Australia

This presentation will describe a series of case studies where spatial technology and mobility tools have been used to make major steps forward in managing pests, environmental health and biosecurity. With high quality, complete and current data flowing directly from multiple field inspectors and technicians to a central database, analysis can be performed much more quickly. Response to serious health threats can be intelligently directed over large areas and targeted to where it has most effect. Trends in environmental damage can be seen early and action can be taken. Chemical treatment and controlled burning can be carefully managed to protect endangered species, assets and people. Regional government authorities can standardize and share data over very large areas and the vectors bringing in pests and weeds can be identified by the footprints they leave on a map.

13 • IPM finds food safety

Room 155F

The food industry is under growing pressure from regulators and consumers to increase food safety. At the same time,

trends toward globalization of food commerce are adding new challenges to the mix. The demand for reduced or more regulated pesticide use increases the pressure to implement effective and efficient IPM programs. Using new technologies and improved analysis of trending data, both of these related challenges can be served.

Organizer: James E. Sargent, sarge@copesan.com, Copesan Services, Menomonee Falls, WI

3:00 13.1 Using data to guide IPM decisions, Mark D. Sheperdigian, shep@rosepest.com, Rose Pest Solutions, Troy, MI

IPM is an ongoing, dynamic system that requires regular reviews and adjustments to maintain optimal results. If you are not using data to guide your IPM program, you are flying by the seat of your pants. Coordinating pest activity with biotic and abiotic factors such as seasonality, weather, human activity, etc. can allow the program coordinator to identify pest sources, easy fixes, permanent solutions and problematic situations. In successive years, data will validate previous adjustments or indicate where more effort is necessary.

3:30 13.2 Bewitched, bothered, and bewildered: Using pheromones, Jeffrey A. Weier, jweier@spraguepest.com, Sprague Pest Solutions, Tacoma, WA

Pheromones have been used in pest management for over 40 years as part of IPM programs. They have proven to be extremely effective for detection and monitoring of pest populations as part of the input for decision making in IPM. The monitoring technology is advancing with more effective devices and better methods for interpreting the data. The most significant advance has been developing systems that use pheromones as a control measure. These mating disruption systems are low risk, low impact, extremely effective, and fit in all IPM, Green and organic programs.

4:15 13.3 The ins and outs of building design: A foundation for pest management, Patricia Hottel, pathottel@mccloudservices.com, McCloud Services, South Elgin, IL

This session will focus on the importance of building design in food facilities as a critical element for pest prevention and control. The proper design process starts with site selection and continues through the selection of building materials and construction. Interior and exterior design considerations will be reviewed including landscaping choices. Food processing plants will be divided into two basic categories: wet processing and dry processing. The differences in pest pressures and design considerations for dry processing plants versus wet processing plants will be reviewed.

4:45 13.4 Pest management partnerships for food safety success, James E. Sargent, sarge@copesan.com, Copesan Services, Menomonee Falls, WI

Food company marketing departments often promote the company's environmental stewardship as well as their production of safe, healthy food products. These food companies solicit pest management service providers who say that they can provide IPM. However, a pest management company can't do IPM alone. It requires commitment and participation by the client; otherwise pest management (and then food safety) will fail. For example, the client has major responsibilities for structural integrity and exclusion, maintenance, cleaning and sanitation, drainage, lighting, landscaping, employee behavior, and other important components of a successful IPM program. Partnerships are critical.

14 • IPM Working Group success stories

Room 155A

The North Central IPM Center has provided competitive funding for 16 Working Groups since 2005, both commodity (fruit, vegetable, field crops, etc.) and non-commodity (Native American, weather, and school IPM, etc.) based. Working Groups range in size from 4 to 150 members, are multi-state, multidisciplinary, and often international collaborations of university researchers, Extension educators, and other stakeholders. Our mission is to enhance communication between members and develop specific resources for growers to use across the region. Leaders of three long standing Working Groups, the North Central Extension Entomologists, Great Lakes Fruit, and Great Lakes Vegetable, will discuss their overall approach to managing Working Groups, their synergies and accomplishments over the years. Examples from past and current activities by the Working Groups will be highlighted including the importance of face-to-face annual meetings, multi-state demonstration projects, their role in establishing the Journal of IPM, the development of regionally relevant educational tools like pocket guides and fact sheets, and newer digital forms of communication including smartphone apps, webinars, and instructional videos that arise from joint research and Extension projects funded through collaborative grants that serve the region.

Organizers: James Jasinski, jasinski.4@osu.edu, Extension, Ohio State University, Urbana, OH; Robert Wright, rwright2@unl.edu, Entomology, University of Nebraska-Lincoln, Lincoln, NE; Julianna Wilson, jkwilson@msu.edu, Entomology, Michigan State University, E. Lansing, MI

4:15 14.1 The North Central Extension Entomology Working Group, Robert Wright, rwright2@unl.edu, Entomology, University of Nebraska-Lincoln, Lincoln, NE; Erin Hodgson, Iowa State University

The North Central Extension Entomology Working group goals are to share information among members, and foster collaborative efforts to address priority Extension needs on field crops in the region. We share information through a wiggio.com platform, regular teleconferences during the growing season and an annual meeting. Recent activities of the working group include co-organizing a 2014 webinar on stored grain insect management, a symposium on management of stink bugs in crops at the 2014 North Central Entomological Society of America annual meeting, and mini-Symposium on Insurance Use of Pesticides at the 2012 International IPM Symposium.

4:30 14.2 The Great Lakes Fruit Working Group, Julianna Wilson, jkwilson@msu.edu, Entomology, Michigan State University, E. Lansing, MI

The Great Lakes Fruit Workers (GLFW) has met annually since 1998 to discuss challenges common to fruit production in the Great Lakes Region and to share late-breaking research and extension tools. The mission of the GLFW is to improve the sustainability of fruit production in the region by fostering collaborations among researchers, extensionists, and independent field consultants. Recently the group developed a new online search tool for tree fruit pests and diseases. An active listerv of more than 200 members is maintained as a means for communication among colleagues throughout the year reporting first alerts of pests and diseases.

4:45 14.3 The Great Lakes Vegetable Working Group, James Jasinski, jasinski.4@osu.edu, Extension, Ohio State University, Urbana, OH; Brad Bergefurd, Ohio State University

The Great Lakes Vegetable Working Group is a network of vegetable specialists (entomology, plant pathology, weed science, horticulture) throughout the region who address current issues facing growers and the vegetable industry. Our WG was formed in 2005 and have held an annual meeting plus completed a tangible "product" every year since. The presentation will cover a range of products including pest management surveys, turn key programs for state and regional vegetable meetings, multi-state vegetable trials, factsheets, pocket guides, and recently we experimented with developing natural enemies and regional pest management smart phone apps for the region.

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15 • Integrated management of Plant Disease Vectoring Pests: Asian citrus psyllid, glassy-winged sharpshooter, *Bemesia tabaci*, flower thrips, and potato psyllid

Room 155A

Integrated management of insect pest vectors of plant diseases is a challenge considering that in some situations there may not be thresholds or tolerances for such pests. Thus, integration and utilization of pest biology, the environment and control tactics becomes more challenging compared with situations where disease is not involved. Usually, commonly available tactics such as chemical control are preferred in decision making and their use increases with time, along with the fear of disease spread and loss in production. Over time, problems such as pest resistance, diminishing populations of beneficial insects and secondary pest outbreaks surface, making situations more complicated and warranting IPM. Examples of economically important disease vectoring pest challenges are plentiful, including the Asian citrus psyllid vector of devastating huanglongbing or citrus greening disease, citrus leafminer which exacerbates citrus canker, sharpshooter leafhoppers or spittlebugs vectors of Pierce's disease of grape and others, such as aphids, whiteflies, leafhoppers and shieldbugs that play their part in several agro-ecosystems. Development and implementation of IPM with participation of stakeholders may be critical for such situations. In this symposium key researchers and extension specialists will be invited to discuss advances and challenges in the development and implementation of IPM for disease vectoring insects.

Organizers: Jawwad A. Qureshi, jawwadq@ufl.edu, Southwest Florida Research and Education Center, University of Florida-IFAS, Immokalee, FL; Norman C. Leppla, ncleppla@ufl.edu, Entomology and Nematology, University of Florida, Gainesville, FL

9:45 15.1 Integrated management of Asian citrus psyllid, Jawwad A. Qureshi, jawwadq@ufl.edu, Southwest Florida Research and Education Center, University of Florida-IFAS, Immokalee, FL; Philip A. Stansly, University of Florida-IFAS, Southwest Florida Research and Education Center, Immokalee FL

Asian citrus psyllid (ACP) threatens citrus throughout Asia and the Americas as vector of huanglongbing (HLB) or citrus greening disease. Vector control is critical to reduce disease spread and also extend productivity in high incidence orchards. Biocontrol provides important ACP mortality but is inadequate alone. Cultural controls include reflective mulch for young trees and enhanced nutrition to mitigate HLB symptoms. Insecticidal control is most effective when adults are few and other life states largely absent due to lack of foliar flush, but repeated sprays are increasingly common. Integrating all into sustainable IPM systems remains a major challenge in affected areas.

10:05 15.2 Is vector control sufficient to limit pathogen spread in vineyards?, Matt Daugherty, matt.daugherty@ucr.edu, Department of Entomology, University of California, Riverside, CA

Vector control programs, though considered integral to disease management, rarely evaluate the consequences for pathogen spread. We surveyed 34 California vineyards to assess the epidemiological value of glassy-winged sharpshooter

(*Homalodisca vitripennis*) chemical control. Imidacloprid reduced vector pressure, but effects on Pierce's disease spread were mixed. Prevalence depended on treatment history the preceding five years, with more diseased vines in untreated vineyards, but yearly incidence was low and did not depend on insecticide treatment. The modest effect of vector control is likely attributable to the currently low sharpshooter densities stemming from area-wide control, without which vector control might be more critical.

10:25 15.3 Advent of biologically based management systems for *Bemisia tabaci* and tomato yellow leafcurl virus, Philip A. Stansly, pstansly@ufl.edu, Southwest Florida Research and Education Center, University of Florida-IFAS, Immokalee, FL

Bemisa tabaci is a key pest of tomato worldwide, principally due to its role as vector of tomato yellow leafcurl virus (TYLCV). Cultural controls include avoidance through fallows in the open field and/or netting in protected production. Biological control through augmentation of parasitoids, and especially mirid predators, is widely used in greenhouse production but not yet in the open field where insecticidal control is largely depended upon, especially with soil applied systemics. TYLCV-resistant varieties are available but may be lacking other desired qualities. Improved varieties would open the way to greater acceptance and success of biologically based IPM.

11:00 15.4 Challenges and opportunities for managing thrips and tospoviruses, Joseph E. Funderburk, jef@ufl.edu, Entomology and Nematology, University of Florida, Quincy, FL

Flower thrips attributes of polyphagy, rapid development, high fecundity, an ability for rapid dispersal, and rapid development of insecticide resistance makes management a serious challenge. This is further complicated in situations where tospviruses are pests. Successful strategies involve define pest status (economic thresholds); increase biotic resistance (natural enemies and competition); integrate preventive and therapeutic tactics (scouting, ultraviolate-reflective technologies, biological control, compatible insecticides, companion plants, and fertility); and vertically integrate with other pests. Such systems are effective, economical, and sustainable.

11:20 15.5 Advances in IPM for the potato psyllid, John T Trumble, john.trumble@ucr.edu, Department of Entomology, University of California, Riverside, CA; Sean Prager, Department of Entomology, University of California, Riverside, CA

By the late 1990s, the tomato/potato psyllid began transmitting a then unknown pathogen that caused millions of dollars in losses in potatoes in Texas. Within less than 5 years the psyllid was causing up to 85% losses in tomatoes in Mexico and California. Losses subsequently were reported in all potato producing states in the US, throughout Central America, and in New Zealand. This lead to intensive pathology, epidemiology, and ecology studies that resulted in the psyllid IPM strategies reported here.

11:40 15.6 Discussion

16 • Reaching new audiences: Innovative strategies to communicate IPM

Room 155B

In the field of integrated pest management, one challenge is to reach members of the general public, especially when they don't have a pest problem. However, increased awareness of IPM extension programs can lead people to seek out extension resources when they do have pest questions. Many IPM and extension programs are using social media, visual tools, and smart device applications to compete in an information driven world where getting attention is a challenge. This session will focus on outreach activities of various programs that have employed social media such as Facebook, YouTube and Twitter, developed applications to help pest managers in the field and will highlight many of the new materials that engage the public where they live, work and play. Topics will include the promotion of higher turf mowing heights through distribution of a measuring card, invasive species outreach with a smart device application, posters and identification card decks, image-based bed bug management and self-protection outreach for low literacy audiences, an IPM image gallery that entices its viewers back to extension for more information, and using golf courses as living classrooms to promote IPM strategies and environmental awareness. Additionally the success of outreach through Facebook, YouTube and Twitter will be discussed.

Organizers: Jody L. Gangloff-Kaufmann, jlg23@cornell.edu, New York State IPM Program, Cornell University, Babylon, NY; Mary K. Malinoski, mkmal@umd.edu, University of Maryland Extension, University of Maryland, Ellicott City, MD

9:45 16.1 Beyond the links: Using golf courses for education and outreach, Joellen K. Lampman, jkz6@cornell.edu, New York State IPM Program, Cornell University, Albany, NY

Seen by many as the epitome of a great lawn, golf courses can provide a valuable backdrop for teaching the general public about integrated pest management. From passive education, such as signs and displays, to larger community events, this presentation will highlight how golf courses have been successfully used to promote environmental stewardship across the world.

10:00 16.2 Poster series as tools for educating the public for a sustainable landscape, David L. Clement, clement@umd.edu, University of Maryland Extension, University of Maryland, Ellicott City, MD; Mary K. Malinoski, University of Maryland Extension

The educational poster outreach tools presented here were originally developed by the Northeast IPM Sustainable Landscape IPM Working Group. The first poster set promotes correct mowing height and sustainable lawn care practices. The second poster set are 5 trees, 5 shrubs, and 5 herbaceous perennials that are considered relatively pest-free and low maintenance. A third poster set consists of 5 common pest control issues in the home and landscape. All posters are available for download on the University of Georgia's Center for Invasive Species and Ecosystem Health, (Bugwood.org) web site: presents.bugwood.org

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11:00 16.3 A new approach to bed bug outreach, Matt J. Frye, mjf267@cornell.edu, New York State IPM Program, Cornell University, Elmsford, NY

Bed bugs have reemerged as a pest and are found in all segments of society. This resurgence has prompted the development of new extension resources that address bed bug management. However, standard fact sheets that rely on text are not available in all languages, and are not practical for low-literacy individuals. To overcome these challenges, we developed a series of ten image-based fact sheets called "Bed Bugs Illustrated," which uses pictures to convey inspection and management techniques. Fact sheets are also available in Prezi, allowing individuals to view bed bug management one step at a time.

11:20 16.4 Extension outreach tools for invasive pests and diseases, Mary K. Malinoski, mkmal@umd.edu, University of Maryland Extension, University of Maryland, Ellicott City, MD; David L. Clement, University of Maryland Extension

The Mid-Atlantic Early Detection Network (MAEDN)) iPhone and Android apps were developed by the Center for Invasive Species and Ecosystem Health (Bugwood.org) are available for free download. The apps enable accurate reporting and location of new invasive species to key local experts, and state and federal, agencies. In addition, sets of color identification cards featuring eight key invasive insects and diseases and a QR tag with a link to the Bugwood App site at: http://apps.bugwood.org/mid_atlantic.html. New invasive posters have also been produced are available at presents.bugwood.org. The project was supported by a USDA Regional IPM Grant.

11:40 16.5 The IPM image gallery: Successes and challenges in social media outreach, Jody L. Gangloff-Kaufmann, jlg23@cornell.edu, New York State IPM Program, Cornell University, Babylon, NY

Traditional extension has long relied on fact sheets and other writing to extend information to those not attending lectures and demonstrations. In our experience, people with pests seek information and people without pests do not. In order to capture the attention of those unfamiliar with IPM, we began a project to host IPM images online, coupled with detailed descriptions, IPM information, searchable key-words and links to science-based IPM information. Visitation to the photo-hosting site is promoted by linking images to other social media, including blogs and a Facebook page. Successes and challenges to this outreach approach will be discussed.

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17 • IPM is critical to managing pest resistance in transgenic crop production systems

Room 155C

It is estimated that by 2050 the world will have to feed 3 billion more humans on significantly less arable land. Raising global productivity to meet the food and fiber needs of this population will require a broad range of agricultural technologies including reliance on transgenic crops designed to control pests and deliver desired yield beyond that of today's elite crop germplasm. Growers have rapidly adopted transgenic crops since their introduction in 1996 because of their consistent, high levels of efficacy and tremendous ease to use. Transgenic crops have increased grower reliance on fewer pest management tools including the use of one herbicide (glyphosate) and one class of insecticides (Bts) and decreased grower use of IPM. This change in grower practices has led to development of weed and insect resistance that now threatens to reduce longevity and tremendous value of current transgenic crop technology. The symposium will be comprised of a series of presentations about current status of pest resistance in transgenic crops and supporting the principle that integrating crop herbicide tolerance and insect resistance traits, pesticides with multiple modes of action, and biological, mechanical and cultural methods to manage pests provides great promise to mitigate, and perhaps reverse, pest resistance prevalence. Adherence to IPM offers growers the clear opportunity to protect transgenic crop culture and long-term crop production sustainability. Public and private organizations must work together to support and stimulate growers to apply IPM in transgenic crop production systems to meet the global food production challenge.

Organizers: Robert A. Masters, ramasters@dow.com, and Jonathon M. Babcock, jmbabcock@dow.com, Crop Protection Research and Development, Dow AgroSciences, Indianapolis, IN

9:45 17.1 Global update on insect-resistant crops: Capitalizing on successes and learning from mistakes, Blair D. Siegfried, bsiegfried1@unl.edu, Department of Entomology, University of Nebraska, Lincoln, NE

Transgenic plants for insect pest control have become an important component of a number of crop production systems. Resistance management has been and continues to be an important consideration in the registration of transgenic plants expressing protein toxins from *Bacillus thuringiensis*. In some instances, target pests have remained susceptible to these technologies and even resulted in area wide population

suppression. However, instances of field-evolved resistance to Bt crops has increased substantially in recent years and has become a major obstacle to continued success of this technology. Examining the factors that have resulted in both successful and unsuccessful resistance management should provide insight into sustainable approaches to using the technology.

10:00 17.2 Global status of herbicide-tolerant crops and herbicide resistance weed research, Philip Westra, Philip.Westra@ColoState.edu, Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO

Weed management represents significant costs for crop producers and is increasingly being complicated by development of herbicide resistance in key weeds. Herbicides have been critical to the development of more environmentally stable crop production systems with benefits from soil and water conservation. Most countries that rely heavily on herbicides for weed management now face newly evolved resistant weed species. The rapid adoption of transgenic crops with resistance to one or more herbicides has resulted in more frequent selection pressure for resistance in key weeds. These issues call for integrated weed management approaches to help protect the utility of key herbicides.

10:15 17.3 A tale of two acronyms: IRM is long-term, area-wide IPM, David W. Onstad, david.onstad@pioneer.com, DuPont Agricultural Biotechnology, DuPont, Wilmington, DE

Once we realize that insect resistance management is long-term, area-wide IPM, we also recognize that effects of resistance management on goals of stakeholders, including economic goals, are the same as those we consider in traditional IPM. Furthermore, we must understand how multiple IPM tactics can improve IRM that is often focused only on the main selective agent. In some cases, the integration of IPM tactics has been considered in mathematical models used to predict the durability of insecticidal crop traits. Examples from the literature will be discussed.

10:30 17.4 IPM in the transgenic era: A realistic assessment of integration in commercial corn and soybean production, Michael E. Gray, megray@illinois.edu, Department of Crop Sciences, University of Illinois, Urbana, IL

The rapid adoption of transgenic corn and soybean since the mid-1990s throughout the United States has transformed the manner in which pests are managed. Traditional integrated pest management (IPM) that relied upon scouting fields, identifying insects (pests and beneficials), and making rescue treatments based upon knowledge of economic thresholds is becoming increasingly irrelevant. A new pest management paradigm has emerged—one in which the selection of transgenic seed months in advance of the growing season largely determines the pests that will be targeted for control. The implications of this revolutionary change with an emphasis on the Corn Belt will be discussed.

11:00 17.5 IPM: The solution to herbicide resistance, A. Stanley Culpepper, stanley@uga.edu, Department of Crop and Soil Sciences, University of Georgia, Athens, GA

A decade and over $1 billion have been spent to manage glyphosate-resistant Palmer amaranth by the Georgia cotton industry. Many have called Palmer amaranth a superweed, some have called it cancer, while it really is just a biological stud. Improved management has been amazing through implementing diverse programs including herbicides, hand weeding, tillage, and cover crops. Growers who have 1) developed sound management programs, 2) implemented these programs in a timely fashion, and 3) removed Palmer amaranth escapes prior to seed production now have the upper hand. However, challenges are still great as economically effective solutions remain elusive.

11:15 17.6 Regulatory emphasis on IPM and pest resistance, Mark A. Peterson, mapeterson@dow.com, Crop Protection Research and Development, Dow AgroSciences, Indianapolis, IN; Bo Braxton; Nicholas Storer

The long term viability of pest management technologies has increasingly become an area of concern among farmers, public researchers, industry, regulators, and the public in general. Recent statements and actions by US Federal Regulators have demonstrated a commitment to take action in the area of mitigating pest resistance to new products, especially those that are enabled by biotech traits. Successful management of pest resistance depends on diversification of control tactics. Current efforts by industry, academics, and regulatory officials are attempting to discover ways to implement practical pest management programs that farmers can implement to the benefit of all stakeholders.

11:30 17.7 IPM is essential to sustainable transgene crop production systems, Robert A. Masters, ramasters@dow.com, Crop Protection Research and Development, Dow AgroSciences, Indianapolis, IN; Jonathon M. Babcock

Sustainable transgenic crop production systems will be more dependent on IPM in the future. There is a need to understand the factors hindering grower adoption of IPM and then lower these obstacles. A renewed focus on widespread adoption and implementation of IPM will help address global challenges of human population growth, fixed or declining arable land, changing climate, public perceptions about adverse impacts of agriculture and pest resistance. Raising global productivity to meet food and fiber productions needs of a rapidly growing population will require a broad range of agricultural technologies including reliance on transgenic crops to deliver desired yields.

18 • Does collaboration make IPM work?—Stories from OECD countries, Europe and Canada

Room 155D

With the changing landscape of the agricultural value chain and increasing demand for sustainable crop production, a continuing theme for discussion has been the question of what it takes to increase adoption of IPM at the farm level. Technically, IPM entails the integration of best management practices by the grower. However, it also requires an integration of support and efforts among all stakeholders to enable and advance uptake of IPM practices by growers. While research into new IPM techniques is an ongoing requirement, there are still enormous gains to be made via diffusion of established practices through networking and collaborations. This session will examine the hypothesis that collaboration is a pre-requisite for successful, on-going adoption of IPM. Collaborations, in the form of expert networks within and across national borders which enable exchange of knowledge, experience and lessons learned are crucial to diffusion of approaches and techniques that work on-farm. Collaborations across the value chain help the grower access the reward for their efforts toward sustainability. The session is organized around four presentations highlighting various international collaboration experiences. One presentation reviews progress resulting from governmental collaboration at the Organization for Economic Co-operation and Development level. The second presentation shows how coordination of resources and information delivery in Europe is helping growers see the benefits of using IPM. Finally, two case studies will illustrate the role of collaboration in delivering successful IPM programs in Canada and Europe. The session will explore ideas to address new challenges for effective transfer of IPM approaches.

Organizer: Cezarina Kora, Cezarina.Kora@agr.gc.ca, Pesticide Risk Reduction Program, Agriculture and Agri-Food Canada, Ottawa, ON, Canada

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9:45 18.1 Organization for Economic Co-operation and Development (OECD) in support of global IPM: A goal to meet pesticide risk reduction challenges, Cezarina Kora, Cezarina.Kora@agr.gc.ca, Pesticide Risk Reduction Program, Agriculture and Agri-Food Canada, Ottawa, ON, Canada; Silke Dachbrodt-Saaydeh, Julius Kühn-Institut, Federal Research Centre for Cultivated Plants, Kleinmachnow, Germany

In October 2011, an international IPM workshop facilitated by the OECD aimed to identify strategies for boosting IPM adoption by growers and its impact in reducing pesticide risks. Several findings, recommendations and an action plan to address recognized gaps resulted from numerous group discussions. In response to one of workshop's recommendations, an Expert Group on IPM (EGIPM) was established to address the need for global collaboration in meeting local challenges in IPM implementation. The EGIPM coordinates contributions from OECD member countries in moving forward various action plan activities. Advancements to date and what these mean on the ground will be discussed.

10:00 18.2 From ENDURE to C-IPM: The power of networking to advance IPM implementation in Europe, Jay Ram Lamichhane, Jay-Ram.Lamichhane@grignon.inra.fr, Eco-Innov, INRA, Grignon, France; Silke Dachbrodt-Saaydeh, Julius Kühn-Institut, Federal Research Centre for Cultivated Plants, Kleinmachnow, Germany; Per Kudsk, Aarhus University, Department of Agroecology, Slagelse, Denmark; Antoine Messéan, INRA, Eco-Innov, Grignon, France

Almost a decade ago, the European Network of Excellence ENDURE successfully linked European institutions committed to IPM research and implementation. Many subsequent European IPM projects such as PURE, build upon the outcomes and lessons learned from ENDURE. Moreover, ENDURE paved the way for C-IPM, a recently established network among 21 European countries aiming to create added value and synergies by coordinating national IPM research and extension capabilities. By making available IPM tools and practices, C-IPM contributes to meeting the challenges of European growers transitioning to mandatory implementation of basic IPM principles following the Directive 2009/128/EC on sustainable use of pesticides.

10:15 18.3 From research to practice: European berry fruit and field vegetables IPM, Nick Birch, nick.birch@hutton.ac.uk, James Hutton Institute, Dundee, Angus, Scotland, UK; Graham Begg and William Deasy, James Hutton Institute

Several EU projects (e.g. PURE) are developing IPM for cropping systems starting with innovative tools and demonstrating best combinations of the 'IPM toolbox' under on-station and on-farm conditions. The approach is collaborative across research disciplines (e.g. plant breeding and genetics, chemical ecology, behavioural ecology, modelling, agronomy) and among EU partners, involving researcher-farmer-policy maker 'co-innovation' from the start. An example will illustrate a raspberry IPM system using pest-resistant varieties, biocontrol, biopesticides and biomimicry-based trapping/monitoring. A second example, based on brassica vegetables IPM from PURE will illustrate how chemical ecology could lead to future IPM strategies for a key pest, cabbage root fly.

10:30 18.4 From SIR with love: Taking a successful Canadian grassroots area-wide IPM program global, Cara Nelson, CNelson@oksir.org, Okanagan Kootenay Sterile Insect Release (OKSIR) Programme, Kelowna, BC, Canada

Though unlikely bedfellows, local taxpayers, researchers, orchardists, and city councilors partnered to create the

world's most successful, longest-running truly area-wide IPM program. Using sterile insect release (SIR), among other technologies, the program has reduced by 96% the pesticide use for *Cydia pomonella* control in pome fruits. Building partnerships isn't easy but it's definitely possible. From an eradication pilot for *Cydia pomonella* in New Zealand to European projects aiming suppression of *Drosophila suzukii* and *Rhagoletis completa*, Canadian know-how is contributing to the enormous global potential for area-wide approaches and showing success can be achieved by sharing experiences and adapting lessons learned.

19 • Getting more green in professional pest management—Even for bed bugs

Room 155E

Communicating the concept and value of IPM has been very difficult, in fact almost impossible, to professional pest management consumers. In this session we will discuss overcoming the challenges and achieving the goals of "green" pest management from the perspective of pest management professionals. Then, we will drill down to a specific topic that needs further exploration from a "green" perspective: bed bugs in sensitive environments.

Organizer: Allison Taisey, ataisey@pestworld.org, National Pest Management Association, Fairfax, VA

9:45 19.1 Introduction, Allison Taisey

9:50 19.2 Green matters: Overcoming the challenges and achieving the goals of "green" pest management, Jeff Weier, jweier@spraguepest.com, Sprague Pest Solutions, Tacoma, WA

Since the beginning of the IPM movement, professional pest management has struggled to communicate the concept of IPM, as well its value to consumers. The industry found, one of the best ways to connect consumers with the values supporting IPM is by branding services with some form of "green." However, since this word has no definition and can lead to regulatory action against companies by the FTC, how does the PMP industry stay out of trouble while ensuring the one mechanism for communicating a special type of service retains its value for the future?

10:15 19.3 Bed bugs in sensitive environments: Can green matter when dealing with public health pests?, Mark Sheperdigian, shep@rosepest.com, Rose Pest Solutions, Troy, MI

As the body of knowledge surrounding bed bugs continues to grow, we find our approach to bed bug management needs to change. This is especially true in the case of sensitive environments. The emerging picture of bed bugs reveals an insect that is better at traveling than it is at arriving. The typical response to bed bug introductions in health care facilities, schools and other sensitive environments is more appropriate for infested domiciles and other areas where bed bugs exist as breeding populations. This presentation explores bed bug management in sensitive environments and its contrasts with residential environments.

20 • Socio-economics and opinion research as strategic tools for IPM: Values and drivers to enhance planning, adoption and tech transfer

Room 155F

IPM and sustainable pest management is a necessity for modern food production throughout the globe. IPM tech transfer and success is said to be based on innovative technologies, outreach and sound policy, all factors of crucial importance. But scientists, policy makers and practitioners usually forget other disciplines in the social sciences when assessing critical issues in the adoption of sustainable practices for pest management. We present and discuss some of our research (we invite colleagues to do the same) regarding the importance of socio-economics and opinion research in IPM adoption and decision making. Strategic planning, decision making, communication and adoption of newer technologies or systems cannot be fulfilled if policy makers, regulators, pesticide companies do not understand the needs and wants of key stakeholders in agriculture and IPM. Our research shows that entrepreneurs, academics, researchers can link with farmers, consultants and distributors, who have a deep understanding of the socio-economics of their crops and pest management tools, holding deep values, opinions and drivers worth knowing and understanding. We highlight the importance of sound methodologies such as opinion research and experience as a fundamental element for strategic planning, policy and regulatory design, communication and sound technology transfer. Our research shows how social, economic and strategy research becomes an essential tool for successful IPM innovation, adoption and implementation. Values and drivers of key stakeholders need to be understood in depth to maintain healthy IPM programs.

Organizer: Dan Badulescu, columbus@columbus-grp.com, H&A Columbus Development, Ltd, Vancouver, BC, Canada

9:45 20.1 Introduction, Dan Badulescu

IPM is a necessity in sustainable food and fiber production. Heavy research and investments in academia and/or industry drive innovators and entrepreneurs, who look to offer solutions for global growers. Emerging technologies are designed and rolled out sometimes without success. Many innovations remain in journals or have only been partially adopted, despite their apparent usefulness. This is not due to technical shortcomings, but the consequence of a lack of understanding of social and economic values systems of opinion leaders and stakeholders which hinders emerging technologies adoption. Emerging technologies require an early process of stakeholder engagement in order to gauge their opinions and value systems. Opinion and qualitative research allows for sound

stakeholder value's assessment and for communication fine tuning. We share our most recent engagement experiences with horticultural growers, highlighting the relevance of qualitative opinion research for strategic communication, marketing and adoption of IPM tools.

10:05 20.2 Botanicals and other innovative alternatives to conventional pesticides, Murray Isman, murray.isman@ubc.ca, Faculty of Land & Food Systems, University of British Columbia, Vancouver, BC, Canada

Collaborations between the university and multiple industrial partners over 25 years has allowed us to investigate the development of botanical insecticides from numerous plant sources from initial discovery through to commercialization. Our research has focussed on behavioral and physiological effects of plant defensive chemicals in insects, characterized habituation to feeding deterrents in insects, explored the pharmacokinetics, metabolism and fate of plant chemicals in insects, elucidated mechanisms of synergy among plant chemicals, and demonstrated that mixtures can mitigate the development of resistance in insect populations. One key question remains—how do we identify social and economic determinants for the adoption of these innovative technologies and approaches. There seems to be a growing opportunity around stakeholder engagement and opinion research that could help facilitate the movement of alternative products/technologies into the marketplace.

10:25 20.3 Developing markets in Latin America for IPM—Getting to know stakeholder's opinion for organic, Jorge Berni, jberni@bernilabs.com, Board, Berni Labs, Aguascalientes, AGS, Mexico

For over 3 decades, our group has been researching and developing botanicals (essential oils) and organic pest management technologies for Latin American markets. Our beginning took place at a time when these concepts were emerging with consumers pushing a new drive for safer, healthier foods. Getting to know values, perceptions and opinions of stakeholders has been a crucial but neglected aspect in our industry. We are convinced that knowing and understanding how regulators, consumers, major chemical companies, growers and consultants think about our developments would have made a big difference. We share our experiences, based on a better engagement with opinion leaders through in-house, experiential opinion research.

11:00 20.4 From scouting to intelligent pest monitoring systems: How adoption can hinge on opinion research, Saber Miresmailli, saber.miresmailli@ecoation.com, Ecoation Innovative Solutions, Inc, Vancouver, BC, Canada

Through his concept of intelligent pest monitoring system, Saber Miresmailli, has developed a novel technology potentially reducing pest management costs by 70% and crop losses by 90%. IPM relies heavily on scouting and monitoring, an aspect that has so far been left unattended in innovation.

Scouts take up to ten weeks to inspect plants in greenhouses. EIS' tech cuts the process down to three days—from analyzing plant-generated signals, discerning between a false alarm, to issuing alerts for growers— before pests or symptoms become visible to the eye. EIS is working to know growers' and IPM practioners' technical & socio-economic value systems, a key resource to roll out tailor-made solutions addressing specific pest management needs for successful adoption. We discuss some potential advantages and hurdles.

11:20 20.5 Discussion

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21 • IPM research projects in the UK and the southern Caribbean

Room 155D

This session will highlight research being done in the UK and the southern Caribbean. The UK research focuses on control of *Drosophila suzukii* and the small hive beetle (*Aethina tumida*). The southern Carribean research tested the efficacy of an extract of the brown seaweed *Ascophyllum nodosum* as a potential plant growth stimulant and disease resistance activator in controlling disease problems in tomato production.

Organizer: Andrew G.S. Cuthbertson, andrew.cuthbertson@fera.gsi.gov.uk, The Food and Environment Research Agency, National Bee Unit, Sand Hutton, York, UK

11:00 21.1 Screening potential products for control of *Drosophila suzukii* in the UK, Andrew G.S. Cuthbertson, andrew.cuthbertson@fera.gsi.gov.uk, The Food and Environment Research Agency, National Bee Unit, Sand Hutton, York, UK; Neil Audsley

Drosophila suzukii has been recorded in the UK since the end of 2012. To date, reports of serious damage have been rare. Several products (both chemical and biological) were investigated for their efficacy against different life-stages of the pest. Both direct and indirect exposure to chemical products was assessed. Spinosad, chlorantraniliprole and an experimental product TA2674 showed excellent potential as control agents when used as either a pre or post-dipping treatment for blueberries with mortalities of 100, 93 and 98% mortality, respectively, being achieved following pre-treatment. Direct spray application of all products tested had limited impact upon adult flies. Highest mortality (68%) was achieved following direct application of TA2674. Entomopathogenic agents (nematodes and fungi) tested appeared to reduce fly population development (ranges of 34-44% mortality obtained) but would seem unable to eradicate outbreaks. In regards to commercially available predatory species the following were evaluated for their potential to act as control agents for *D. suzukii*: *Orius majusculus*, *Orius laevigatus*, *Atheta coriaria*, *Hypoaspis miles* and *Anthocoris nemoralis*. This set of natural enemies could

potentially target several life stages of *D. suzukii* (larvae, pupae and adults). All species, except *H. miles*, fed on *D. suzukii* life stages to some extent. *Hypoaspis miles* displayed no impact upon *D. suzukii* populations. *Anthocoris nemoralis* displayed a tendency to feed upon more male than female adult *D. suzukii* and caused 45% mortality after five days. The potential of the screened products to control *D. suzukii* populations is discussed. Acknowledgements: The research leading to these results has received funding from the European Union's Seventh Framework programme for research, technological development and demonstration under grant agreement number 613678 (DROPSA).

11:15 21.2 Contingency planning for small hive beetle *Aethina tumida* in the UK, Andrew G.S. Cuthbertson, andrew.cuthbertson@fera.gsi.gov.uk, The Food and Environment Research Agency, National Bee Unit, Sand Hutton, York, UK

The small hive beetle (*Aethina tumida*) is an endemic parasitic pest and scavenger of colonies of social bees indigenous to sub-Saharan Africa. In this region the beetles rarely inflict severe damage on strong colonies since the bees have developed strategies to combat them. However, *A. tumida* has since 'escaped' from its native home and has recently invaded areas such as North America and Australia where its economic impact on the apiculture industry has been significant. It has now recently also been recorded in Europe (Italy). Commercially available entomopathogenic nematodes within the UK were screened for their potential to control beetle larvae. The nematodes *Steinernema kraussei* and *S. carpocapsae* provided excellent control with 100% mortality of larvae being obtained. A dose rate of *S. kraussei* at 2,500 IJ/ml still provided complete larval mortality. Delayed applications of the nematodes following larvae entering sand to pupate also provided excellent control for up to 3 weeks. Evidence that the nematodes could still enter pupating larvae after 3 weeks in the ground was obtained. The information gained supports the development of contingency plans to deal with *A. tumida* should it occur in the UK. Acknowledgements: The work is funded by the Department of Environment, Food and Rural Affairs (Defra), UK.

11:30 21.3 Use of Ascophyllum seaweed extract as bioelicitor or biostimulant in tomato production in the southern Caribbean, Jayaraj Jayaraman, jayauwi@gmail.com, Department of Life Sciences, Faculty of Science and Technology, The University of the West Indies, St. Augustine, Trinidad and Tobago; Nerissa Ali; Adesh Ramsubhag

Tomato production in Trinidad and Tobago is challenged by disease problems which requires a sustainable and integrated approach of control employing environmental friendly methods particularly with minimum of usage of chemical fungicides. In the present study, we have tested the efficacy of an extract of the brown seaweed *Ascophyllum nodosum* as a potential plant growth stimulant and disease resistance activator. Our extensive studies both in greenhouse and field revealed that the spray application of SWE (0.5%) was more effective than soil drenching. Among the treatments, integrated application of SWE in alternation with minimal fungicide levels was found to be significantly effective in controlling the diseases compared to individual applications. Application of 0.5% SWE significantly increased the plant height by 31% and in plant yields by 50-65% compared to the controls. SWE treated plants had significantly higher shoot length, root length and plant biomass production, higher flower number, flower to fruit ratio and prolonged bearing. Foliar spray of SWE suppressed the incidence of diseases including Xanthomonas leaf spot (44%), reduction of Alternaria blight (64%), and Sclerotium stem rot (70%). The improved disease tolerance of SWE treated plants could be attributed to the phenomenon of induced resistance contributed by increased defence enzyme activities (PPO, PAL, Chitinase, Glucanase, and Peroxidase) and elevation in native total phenolic contents following SWE spray. Q-PCR analyses of SWE-treated plants revealed a significant increase in the transcript levels of induced systemic resistance (ISR) pathway marker genes. The improved growth and biomass production could be correlated to improved chlorophyll content and nutrient mobilization, and growth stimulation by plant hormone-like substances or their analogues found in SWE. Our studies optimized the use of seaweed extract technology for sustainable tomato production in the Caribbean with minimum use of fungicides in an environment-friendly manner.

22 • Inside/outside: How building design and structure can hurt or help IPM efforts

Room 155E

Pests belong; in professional pest management our job is to keep the pests where they belong. Tucker, in Mallis Handbook of Pest Control, 10th ed. states it this way, "The presence of a pest insect or rodent infestation in any building is essentially a symptom of a deficiency in building construction, operation, maintenance and/or sanitation. It is never a symptom of a lack of pesticides." This session explores how building construction can play a critical part in having a successful IPM program. Plus, it looks at how those that want to reduce pesticide usage need to be more active in influencing construction designed to keep pests out.

Organizer: Allison Taisey, ataisey@pestworld.org, National Pest Management Association, Fairfax, VA

11:00 22.1 Introduction, Allison Taisey

11:05 22.2 Interior building design for successful IPM in commercial kitchens, Judy Black, jblack@

steritech.com, The Steritech Group, Broomfield, CO

Implementation of IPM is easier in structures and equipment designed to be unfavorable to pests. For example, facilities provide fewer opportunities for pest food and harborage when, by design, they are easy to clean. Buildings themselves can improve the prospects for decreased pesticide use and greater implementation of IPM when designers plan pest prevention into construction. Thus, new construction, as well as remodeling projects, are critical opportunities to make the facility as hostile to pests as possible. Various examples will be given as well as a "how to" on building a checklist for these types of properties.

11:30 22.3 Exterior building design for IPM success, John Cooksey, jcooksey@Mccallservice.com, McCall Service, Jacksonville, FL

Many interior pests originate on the exterior of the building. Landscaping materials, exterior lighting and ornamental plants growing outside can have an impact on pest attraction. In addition, these materials can impact the survival of the pests attracted to the building by providing food, water and shelter. As pests proliferate, the interior of the structure is placed at greater risk. In this session, we will discuss how plant and landscape material selection affects pest pressures and which materials are less pest friendly. Properly selecting the right lights, landscaping materials and plants are important considerations in a successful IPM scheme.

23 • Two invasive pests that fundamentally changed IPM in fruit and nut crops: Brown marmorated stink bug and spotted wing drosophila

Room 155A

Brown marmorated stink bug and spotted wing drosophila are two invasive pests that both have a wide host range. These pests attack crops internationally, resulting in significant economic damage to fruit and nut crops. In this session we will provide an introduction to these pests. The impact and the crops that they attack will be highlighted. Information of environmental impacts and phenological differences between different production regions will be detailed. We will evaluate the shortcomings of the currently used management practices for both pests. Finally we will consider potentially promising future management practices.

Organizers: Tracy Leskey, Tracy.Leskey@ARS.USDA.GOV, USDA, Kearneysville, WV; Cesar Rodriguez Saona, CRodriguez@AESOP.Rutgers.edu, Rutgers, Chatsworth, NJ; Vaughn Walton, vaughn.walton@oregonstate.edu, Oregon State University, Corvallis, OR

1:45 23.1 Biology ecology and management of the invasive brown marmorated stink bug, Tracy Leskey, Tracy.Leskey@ARS.USDA.GOV, USDA-ARS, Kearneysville, WV

Brown marmorated stink bug (BMSB), *Halyomorpha halys* (Stål), is an invasive pest accidently introduced from Asia into the US. In 2010, outbreak populations of BMSB attacked many crops in the mid-Atlantic region of the US; damage in orchard crops reached critical levels with growers experiencing serious losses in stone and pome fruit. Subsequently, season-long pressure from BMSB has dismantled long-standing IPM programs as growers have responded with aggressive insecticide-based management programs in the absence of effective monitoring tools. Recent advances including the identification of the BMSB pheromone and synergist have now opened the door for IPM-based monitoring and management tools for this invasive pest.

2:05 23.2 BMSB population dynamics in the Western US, Nik Wiman, nik.wiman@oregonstate.edu, Oregon State University, Corvallis, OR; Vaughn M Walton; Peter W. Shearer, Mid-Columbia Agricultural Research and Extension Center, Oregon State University, Hood River, OR

Brown marmorated stink bug (BMSB) took approximately 14 years from its first appearance in 1996 to become a major economic pest in 2010 in the Mid-Atlantic US. On the West Coast of the US, BMSB has been known since 2004 from Oregon and California. Does this mean that we are on the verge of massive economic impacts from BMSB around 2018 on the West Coast? There are interesting comparisons and contrasts to be drawn between the environments and cropping systems of the Western US and Mid-Atlantic regions that may determine population dynamics of BMSB and its pest status in the region.

2:25 23.3 SWD ecology biology and management in small and stone fruit, Vaughn Walton, vaughn.walton@oregonstate.edu, Oregon State University, Corvallis, OR; Daniel T. Dalton; Nik G. Wiman; Samantha L. Tochen; Betsey Miller; Hannah Burrack; Joanna Chiu; Kent M. Daane; Tracy Leskey; Rufus Isaacs; Xin-geng Wang; Peter W. Shearer; Claudio Ioriatti; Gianfranco Anfora; Alberto Grassi; Markus Neteler

Drosophila suzukii, spotted wing drosophila (SWD), is a key insect pest threatening the long-term sustainable production of commercial small fruits in the United States of America. *D. suzukii* is a key pest in all major production areas in the US. A history of the temporal spread of SWD through the US will be described. Fruit damage because of SWD larval development has resulted in a major change in current production practices of berry fruit in the US. These changes have resulted in significant increases in production costs of berry fruit. The nature

of economic impact of SWD to berry production systems will be elucidated. Currently used management strategies will be described including cultural, chemical and biological controls. Promising future management strategies of this pest will be elucidated.

3:00 23.4 Biology and management of spotted wing drosophila in the southeastern United States, Lauren Diepenbrock, laurendiepenbrock@gmail.com, North Carolina State University, Raleigh, NC; Hannah Burrack, North Carolina State University, Raleigh NC

Drosophila suzukii, commonly referred to as the spotted wing drosophila, was first detected in the southeastern United States (Florida) in 2009 and was subsequently found in all states in the region between 2010 and 2012. In the time since *D. suzukii* has been detected, important contrasts between its biology and management in the southeastern United States and other regions of the country. Key among the challenges in the southeastern US are persistence of detectable populations throughout the year, interference of rainfall with management tools, and high overall populations.

3:20 23.5 Organic management of BMSB, Anne Nielsen, nielsen@AESOP.Rutgers.edu, Rutgers, Bridgeton, NJ

Pest management of invasive species is a challenging process, especially when tactics are unavailable. This issue is further exacerbated in organic production where growers rely primarily on biological control, crop rotation, cultural control for management. Organic insecticides, where applied, can reduce injury, but are not as effective as synthetic compounds. A group of 12 US institutions are collaborating on identifying integrative IPM tactics against brown marmorated stink bug (BMSB), an invasive polyphagous pest that is also an issue on organic farms. The potential for trap cropping, enhancing biological control and manipulating insect behavior for BMSB will be discussed.

3:40 23.6 Using the spotted wing drosophila genome to develop novel management approaches, Joanna Chiu, jcchiu@ucdavis.edu, University of California, Davis, Davis, CA

Drosophila suzukii Matsumura (spotted wing drosophila) has recently become a serious pest of a wide variety of fruit crops in the US as well as in Europe, leading to substantial yearly crop losses. To enable basic and applied research of this important pest, we sequenced the *D. suzukii* genome and published a high quality reference sequence. Here we discuss ongoing projects that utilize the SWD genome to study its biology and physiological response to chemical insecticides. The development of novel tools and strategies for managing SWD will also be discussed.

4:15 23.7 Prospects for biological control of BMSB and SWD, Kim A. Hoelmer, Kim.Hoelmer@ARS.USDA.GOV, USDA, Newark, DE; Christine Dieckhoff, USDA Agricultural Research Service, Beneficial Insects Introduction Research Unit, Newark, DE; Kent Daane and Xingeng Wang, Department of Environmental Science, Policy & Management, University of California, Berkeley CA; Emilio Guerrieri and Massimo Giorgini, Institute for Plant Protection, National Research Council of Italy, Portici, Italy; Vaughn Walton, Department of Horticulture, Oregon State University, Corvallis, OR

The invasive brown marmorated stink bug and spotted wing drosophila lack effective natural enemies in the US Exploration in Asia has discovered several species of parasitoid wasps that attack BMSB and SWD in China, Korea and Japan, and which are now in culture at quarantine laboratories in the US for further evaluation and development. BMSB and SWD have many widespread hosts that may provide stable reservoirs for new natural enemies. We present an overview of biological control programs aimed at identifying safe new biocontrol agents that will reduce pest populations and help to integrate the natural enemies into IPM systems.

4:35 23.8 *Drosophila suzukii* overwintering and alternate host biology, Anna Wallingford, akw52@cornell.edu, Cornell University, Geneva, NY; Stephen Hesler, Johanna Elsensohn, and Gregory Loeb, Cornell University, New York State Agricultural Experiment Station, Geneva, NY

Understanding the overwintering biology of the invasive pest, *Drosophila suzukii*, is critical to our understanding of its seasonal phenology in its new geographic range. The role of temperature and photoperiod on reproductive diapause and cold hardiness was investigated in *D. suzukii*. Cool temperatures and short daylengths result in decreased egg production and altered pre-oviposition time in lab-reared and field collected females. Low temperature pretreatments that result in altered reproductive status or external morphology also increased survival after acute cold stress. Several species of alternative hosts were found to be utilized by *D. suzukii*, none of which are likely overwintering sites.

4:55 23.9 Prospect for SWD biological control in western US, Antonio Biondi, antonio.biondi@unict.it, University of Catania, Italy; Xin-geng Wang and Kent Daane, University of California, Berkeley, CA; Betsey Miller, Jeffrey C. Miller, Vaughn Walton, and Peter W. Shearer, Oregon State University, Corvallis, OR; Emilio Guerrieri and Massimo Giorgini, National Research Council of Italy, Portici, Italy; Chia-hua Lue and Matthew Buffington, USDA-ARS, Washington, DC; Kim A. Hoelmer, USDA-ARS, Newark, DE

We surveyed resident parasitoids attacking SWD in California and Oregon, and then compared species composition and abundance to material imported from South Korea. Two resident generalist parasitoid species were found attacking SWD pupae in the western US. Whereas no parasitoids attacked SWD larvae in the western US, several larval parasitoids were found in South Korea. Ongoing California quarantine studies of the effectiveness and specialization of these South Korean parasitoid species may result in their release and improved SWD biocontrol control in Western US.

24 • IPM in a changing urban landscape: Sustainable farming in cities

Room 155B

Farming in urban environments is growing rapidly with community gardens, market gardens, and small scale polyculture farms being incorporated into the landscape. Production occurs at several scales from single vacant lot community gardens to farms extending more than a city block in size. Many cities have adopted policies allowing for the production of crops and animal products in support of improving community nutrition. Access to nutritious food is especially limited in low-income communities, where many residents lack access to personal or public transportation or supermarkets within walking distance that carry fresh produce. The incorporation of local food production in cities is an important component of community food security and requires ecologically and economically sound IPM guidelines. This symposium will explore the challenges faced by in the production of food crops within these small-scale polyculture systems and address how IPM technologies can be applied to advance the sustainability of farming in cities.

Organizers: Mary Gardiner, gardiner.29@osu.edu, Scott Prajzner and Caitlin Burkman, Entomology, The Ohio State University, Wooster, OH

1:45 24.1 Urban vacant lots as a conservation habitat for beneficial arthropods, Mary Gardiner, gardiner.29@osu.edu, Entomology, The Ohio State University, Wooster, OH; Caitlin E. Burkman and Scott P. Prajzner, Department of Entomology, The Ohio State University

Many United States cities have experienced significant economic decline and population loss. This deindustrialization has led to thousands of acres of vacant land. Communities have conceptualized a variety of reutilization strategies for this land, including urban agriculture and the creation of small native plantings. We examined how the redesign of an urban vacant lot affects spider food webs by assessing the diversity and abundance of spiders and their prey within residential vacant lots, community gardens, and planted pocket prairies. We found that maintained vacant lots contained the most active spider assemblage, which was dominated by disturbance-tolerant habitat generalist species. Planted prairies had significantly fewer spiders but the assemblage was the most diverse of the greenspaces examined. Prey availability for sheet web spiders (Linyphiidae) also varied, with vacant lots supporting a higher abundance of Collembola in early summer whereas these prey were more abundant within community gardens in mid and late summer. Given a history of lead contamination within this landscape we also assayed spiders and their prey for lead contamination. We found no difference in the proportion of spiders and prey containing detectable levels of lead, and no difference in lead concentration within these specimens.

2:05 24.2 New York City community gardens: Agroecological characteristics, pest challenges, and opportunities for IPM, Timothy Leslie, timothy.leslie@liu.edu, Biology, LIU Brooklyn, Brooklyn, NY; Megan Gregory, Department of Horticulture, Cornell University, Ithaca, NY; Laurie Drinkwater, Department of Horticulture, Cornell University, Ithaca, NY

In light of the growing interest and participation in urban community gardening, we described the agroecological characteristics of 61 community gardens in New York City and examined environmental factors influencing arthropod pests and natural enemies. Gardens were described using gardener interviews, land use maps, plant species inventories, arthropod sampling and soil analysis. Stepwise multiple regression was used to identify factors that best predicted peak numbers of the most common arthropod groups. Land use and management practices were highly variable among gardens. On average, nearly half of garden area was devoted to food crops, whereas only 20% was devoted to flowers and woody perennials combined. Food crop areas were dominated by Solanaceae, Brassicaceae, and Cucurbitaceae crops, with limited use of crop rotation. In general, soils had low water-holding capacity and had excessive nutrient levels. Insect pest densities often exceeded action thresholds, whereas predator and parasitoid densities were generally low. Several factors related to land use decisions (e.g., floral area) and environmental conditions (e.g., light availability) were identified as predictors of pest and beneficial arthropod abundance. We discuss land use decisions and garden management practices that could be employed for managing pests and improving food production in urban community gardens.

2:25 24.3 IPM for urban and other small-scale farmers in the western US: Challenges and opportunities, Tessa Grasswitz, tgrasswi@nmsu.edu, New Mexico State University, Los Lunas, NM; Diane Alston, Department of Biology, Utah State University, Logan, UT; Ed Bechinski, Division of Entomology, University of Idaho, Moscow, ID; Dan Drost, Department of Plants, Soils and Climate, Utah State University, Logan, UT; Gwendolyn Ellen, Integrated Plant Protection Center, Oregon State University, Corvallis OR; Edmund Gomez, Extension Economics

Department, New Mexico State University, Alcalde, NM; Ramiro Lobo, University of California Cooperative Extension, San Diego, CA; Marcy Ostrom, Department of Community and Rural Sociology, Washington State University, Wenatchee, WA; Doug Walsh, Department of Entomology, Washington State University, Prosser, WA; Cheryl Wilen, University of California Cooperative Extension, San Diego, CA; Cinda Williams, Latah County Extension, University of Idaho, Moscow, ID

Small-scale US farms—particularly urban farms—are frequently characterized by diversity, not only in terms of the crops grown, but also in relation to the demographics and principal occupation of the farmers themselves. Many such growers come from 'non-traditional' farming backgrounds, and may be unfamiliar with extension activities, or hard to reach for other reasons (e.g. language, cultural, or other barriers such as off-farm employment). Such constraints can present challenges in determining and meeting the IPM-related research and extension needs of these producers. On the other hand, small-scale production systems and diverse farmers with non-traditional goals, objectives and backgrounds can provide opportunities to develop innovative solutions to pest management problems that would not be possible or appropriate for larger scale conventional agriculture. This presentation will highlight some of the insights gained by members of the Western Small-farm IPM Working Group into the IPM-related challenges and opportunities associated with urban and other small-scale farming systems.

3:00 24.4 "Vacant to Vibrant" Urban Agriculture Project Inspires Youth Entrepreneurs IPM Adoption, Brad Bergefurd, bergefurd.1@osu.edu, OSU South Centers, Piketon, OH; S.A. Mills-Wasniak; L.A. Nye

In July 2013, The Victory Project, a non-profit mentoring program for at-risk youth, assumed responsibility for the management of the High Tunnel Project. Located on the parking lot of a demolished elementary school, the High Tunnel Project is a partnership between the City of Dayton and Ohio State University Extension. The sixteen youth enthusiastically accepted the challenge. A non-profit focusing on Education, Entrepreneurship, and Enlightenment, Victory Project was a perfect complement to the project goals. As the produce grew and developed the youth saw an analogy to their lives, if you nurture and care for yourself, you grow and develop. A new venture for the youth was to establish a market for their produce. A locally owned nearby restaurant agreed to buy if the quality and quantity of produce was acceptable and priced appropriately. Over 1000 pounds of produce was sold to the restaurant with the remainder donated to food pantries or consumed by the youth. The learning experience included a lesson on the importance of proper pest management to produce a high quality and profitable crop. The 2014 expansion of the project afforded the opportunity for Extension Educators and Specialists to mentor and educate the youth on developing integrated pest and crop management plans including business, site, production, and marketing plans. The vision, mission, and goals of the project focused on developing sustainable educational opportunities for the youth and community, while increasing food production using IPM technology suitable to this unique production site.

3:20 24.5 Urban agriculture resources: IPM challenges and solutions in California, Cheryl Wilen, cawilen@ucanr.edu, University of California Cooperative Extension, San Diego, CA; Rachel Surls, UC Cooperative Extension, Los Angeles County, Alhambra, CA; Gail Feenstra and Sheila Golden, Agricultural Sustainability Institute; Ryan Galt, Department of Human Ecology; Shermain Hardesty, UC Small Farm Program, Department of Agricultural and Resource Economics; Claire Napawan, Department of Environmental Design, UC Davis, Davis, CA

There are a number of challenges for urban agriculture practitioners to obtain appropriate information for pest management in California. Historically, UC Cooperative Extension responded to the needs of large production growers, typically large acreage, monoculture cropping systems in rural areas, and to those of home gardeners who grow food for their own use in smaller plots and a diversity of crops in urban and peri-urban locales. With the recent uptick in interest in commercial farming in metropolitan areas, Cooperative Extension in California is re-defining how its resources are used to better address the needs of these growers who "fall through the cracks." Many of these urban farmers need information about the same pest management tools and regulations when growing crops as large, rural growers. Many are also new to crop production, as are many home gardeners, and need resources to help them identify pests and diseases and determine appropriate management programs. Our recent needs assessment survey for this audience found that educational materials and training in pest management specifically for urban agriculture was ranked as one of the top three needs by both extension personnel and producers. There is a great opportunity for IPM adoption with these new urban farmers through providing IPM material and workshops that address and recognize the diversity of cropping systems and experience of these growers.

3:40 24.6 Urban agriculture IPM challenges, Jacqueline Kowalski, kowalski.124@osu.edu, OSU Extension Cuyahoga County, Cleveland, OH

Cleveland is nationally known for its urban agriculture movement. Ag-friendly zoning laws, multiple direct marketing opportunities and re-greening initiatives have all contributed to a dramatic increase of market gardens, and urban farms within the city limits. The size of the farms currently range from a few raised beds to six acres. Most are mixed vegetable operations that sell product at Farmers Markets or through CSAs.

As with all farms, integrated pest management plays a key role in the long-term success of urban farms. However, there are many challenges to integrated pest management on urban farms such lack of production experience of growers, failure to plan and budget for pest management, and competing expectations of farmers and local government. This presentation will highlight some of the pest management challenges Cleveland farmers encounter and how they are being addressed.

4:15 24.7 Delivery of real-time pest activity to urban producers, Marion Murray, marion.murray@usu.edu, Department of Biology, Utah State University Cooperative Extension, Logan, UT

The Utah IPM Program delivers pest activity information to fruit and vegetable growers as well as the green industry, in a variety of ways. The IPM pest advisory service reaches over 8,000 commercial, residential, and private applicators with free, subscription-based email newsletters that contain pest biology, monitoring tips, treatment timings, threshold recommendations, and control options. A companion website and app, called Utah TRAPs (Temperature Resource and Alerts for Pests) provides degree days, pest phenology, and treatment recommendations for over 50 locations, with a text alert option. The advisories and website are evaluated by a biennial survey.

4:35 24.8 Discussion

25 • Application of entomopathogenic nematodes in IPM

Room 155C

Entomopathogenic nematodes are extraordinarily lethal to many important insect pests, yet are safe for plants and animals. Entomopathogenic nematodes occur naturally in soil environments and locate their host in response to carbon dioxide, vibration and other chemical cues. Species in two families (Heterorhabditidae and Steinernematidae) have been effectively used as biological insecticides in pest management programs. There is no need for personal protective equipment and re-entry restrictions. Insect resistance problems are unlikely. Entomopathogenic nematodes fit nicely into integrated pest management or IPM programs because they are considered non-toxic to humans, relatively specific to their target pest(s), and can be applied with standard pesticide equipment. The infective juvenile nematode, which is the only free-living stage, enters the host via natural openings, i.e., mouth, anus, spiracles, or occasionally through the insect cuticle. Most biologicals require days or weeks to kill, yet nematodes, working with their symbiotic bacteria, can kill insects within 24-48 hours. Entomopathogenic nematodes (EPNs) have been utilized in classical, conservation, and augmentative biological control programs. The vast majority of applied research has focused on their potential as inundatively applied augmentative biological control agents. Extensive research over the past three decades has demonstrated both their successes and failures for control of insect pests of crops, ornamental plants, trees and lawn and turf. Entomopathogenic nematodes have been exempted from the US Environmental Protection Agency (EPA) pesticide registration.

Organizer: Gadi VP Reddy, reddy@montana.edu, Western Triangle Ag Research Center, Montana State University, Conrad, MT

1:45 25.1 Entomopathogenic nematodes: A tool in integrated pest management systems, Parwinder Grewal, pgrewal@utk.edu, Entomology, University of Tennessee, Knoxville, TN

Entomopathogenic nematodes (EPNs) have emerged as excellent tools for IPM systems. EPNs have been shown to be effective against nearly 200 pest species under field conditions. Broad host range and ability to seek and kill insects in soil and in cryptic habitats including roots and tree trunks, where most chemical pesticides fail to reach make EPNs especially attractive. Ease of application via standard pesticide spray equipment and through diverse irrigation systems, and their compatibility with numerous agrochemicals facilitates EPN adoption in IPM systems. Ability to boost plant immunity against a broad spectrum of pests and pathogens further enhances EPN utility.

2:05 25.2 Mass application of entomopathogenic nematodes prevented an outbreak of the pine defoliating sawfly *Acantholyda posticalis* in Finland, Heikki M.T. Hokkanen, heikki.hokkanen@helsinki.fi, Department of Agricultural Sciences, University of Helsinki, Helsinki, Finland; Antti Pouttu; Ingeborg Menzler-Hokkanen

The great web-spinning sawfly is a ubiquitous, notorious pine defoliator occurring from Japan through Asia to Western Europe. It is known to have caused decades-long, sustained and large-scale outbreaks in Central-Europe, and is a constant problem in pine plantations in Russia and in China. An outbreak in Finland started in 2006, and reached severe levels in 2009. Before the next mass outbreak, predicted for 2012, we treated in 2011 and 2012 a total of over 200 ha with *Steinernema feltiae* at the rate of 0.4 million IJ/m2, which stopped the outbreak and protected the pine forests until now.

2:25 25.3 Improving microbial control efficacy of entomopathogenic nematodes in orchard systems, David I. Shapiro-Ilan, David.Shapiro@ars.usda.gov, SE Fruit and Tree Nut Research Unit, USDA-ARS, SAA, Byron, GA

Widespread use of entomopathogenic nematodes as biocontrol agents in orchards and other systems can be hampered by a lack of efficacy relative to competing tactics. There are several approaches to improving entomopathogenic nematode efficacy including: screening strains for the most virulent/effective nematode, creating better nematodes through genetic or non-genetic methods, improving nematode production, formulation and application, and expanding fundamental knowledge

on nematode biology and ecology. These approaches are exemplified in case studies depicting improved use of entomopathogenic nematodes to control pecan weevil, plum curculio, lesser peachtree borer, and peachtree borer, and leveraging fundamental studies on nematode infections dynamics.

3:00 25.4 Integration of entomopathogenic nematodes (EPNs) in large scale agriculture systems, Itamar Glazer, glazerit@volcani.agri.gov.il, Plant Science Institute, The Volcani Center, Bet Dagan, Israel

White grubs of *Maladera matrida* are major soil pests of agriculture crops causing substantial damage to ornamentals, peanuts and sweet potatoes. We evaluate the efficacy and persistence of commercial EPN. The nematodes were applied using different application methods: Spray, irrigation and soil injection. The presence of nematodes in the soil was evaluated using '*Galleria* traps'. Application of *Heterorhabditis bacteriophora*, resulted in 80% reduction in damage to the peanuts with no effect on the yield. Larvae of *Capnodis tenebrionis* invade and cause damage to the roots. Trees can be rapidly killed by this distractive pest. We tested the efficacy of the EPN to control of *C. tenebrionis* larvae inside and outside the tree root system. The experiments were conducted during in a commercial plantation covered with insect proof netting that will be deliberately infested by fertile adult beetles. Nematodes (*Steinernema carpocapsae*, *S. feltiae* and *H. bacteriophora*) were applied at rates of 3×10^6 or 1×10^6 infective juveniles per tree in drench around the trunk of trees. The initial results indicate substantial reduction of insect infection by 70-80%. In all trails, nematodes appeared to be active during the entire growing season. Towards the end of the season, nematode activity was also detected in the un-treated control plots.

3:20 25.5 The potential of entomopathogenic nematodes as biological control of sweet potato weevils and their mechanism of the reduction of weevils' populations in sweet potato fields, Katsuya Ichinose, ichis@affrc.go.jp, Itoman Branch, Kyushu Okinawa Agricultural Research Center, Okinawa-ken, Japan; M. Yoshida; Y. Okada; T. Sakai

We carried out "Push-and-Pull" experiments in sweet potato fields to examine the potential of entomopathogenic nematodes, native to the Nansei Islands located in southern Japan, to control sweet potato weevils of two species, *Euscepes postfasciatus* and *Cylas formicarius*. In these experiments, we established experimental plots, in which three treatments were assigned: only a susceptible cultivar was planted (SC); only a resistant cultivar was planted (RC); the resistant cultivar was planted with surrounded by another susceptible cultivars (RS). Two nematodes were applied to any of these plots, while other plots did not received any nematodes. The damage on tubers by weevils was least in resistant cultivars in RS with nematodes. Susceptible cultivars without nematodes were serious infested by these weevils. We also traced weevils and also collected cadavers of any insects on each plants in these plots for 21 days after the application of nematodes. Cadavers were dissected to examine the infestation by nematodes. The moving distance of weevils were larger in nematode-applied plots, and nematodes were found from weevil cadavers. We also dissected dead immatures obtained from dissected plants, and confirmed infestation of dead immatures by nematodes. These results indicate that the tuber damage in nematode-applied plots was reduced by both the infestation of weevils by nematodes and by exclusion of adults from the plots. We discuss the possible use of these nematodes in sweet potato field.

3:40 25.6 Beneficial nematodes in IPM—An African perspective, Solveig Haukeland, shaukeland@icipe.org; solveig.haukeland@bioforsk.no, African Insect Science for Food and Health, ICIPE, Nairobi, Kenya; D. Coyne; J. Ross

Nematology in most African countries is well below capacity and in need of heightened attention to address major challenges within crop protection in the wake of intensified African agriculture. Plant parasitic nematodes, (*Meloidogyne* spp.), are thriving in horticultural crops on small holder and commercial farms causing unknown levels of damage. IPM is well suited for their management. Entomopathogenic nematodes and nematodes of slugs are excellent biological control components in many IPM systems. Most work on these nematodes is within MSc or PhD studies. A perspective on Nematology in Africa will be presented with examples of current activities on EPN and slug parasitic nematodes, followed by prospects and opportunities for Nematology in Africa.

4:15 25.7 Compatibility of nematodes in conventional programs, Jennifer Bergh, jennifer.bergh@basf.com, BASF Specialty Products, BASF, Corvallis, OR

Entomopathogenic nematodes are being used for control and suppression of a wide variety of insect pests. In greenhouses, good results have been achieved using *Steinernema feltiae* to control fungus gnats and suppress western flower thrips. Two case studies are presented to describe common grower challenges of adoption and keys to success of nematode use in horticultural IPM programs. New Nemasys efficacy data and directions for future studies are discussed.

4:30 25.8 Predaceous nematode: A preliminary investigation as a possible management tool for cabbage maggot in the Salinas Valley of California, Shimat V. Joseph, svjoseph@ucanr.edu, UC Cooperative Extension, University of California, Salinas, CA

Cabbage maggot (CM), *Delia radicum* is a serious pest of broccoli in the central coast of California. Feeding injury from cabbage maggot (CM) could cause serious economic losses to growers. Primarily, the organophosphate insecticides (e.g. chlorpyrifos) have been used to manage CM but with detection

of higher levels of their residues in water bodies, they are heavily regulated. This preliminary project was attempted to develop IPM strategies for CM using non-chemical approaches including predaceous nematode, *Steinernema carpocapsae*. Two field studies were conducted to determine the efficacy of *S. carpocapsae* to CM. Results from both the field studies did not provide evidence of CM suppression using *S. carpocapsae* but more research will be conducted to determine role of predaceous nematodes as a tool to manage CM.

4:45 25.9 Discussion

26 • Innovative bed bug management strategies

Room 155E

Bed bug control is widely regarded as one of the most difficult urban pest to control. Many non-chemical and chemical methods were available for managing bed bugs. Effective management relies on IPM which combines several tools and methods to deliver the most cost effective results. This session will discuss some innovative programs and methods conducted in laboratory and naturally infested apartments. These include: a building-wide monitoring program protocol for detecting bed bug infestations; a treatment protocol to achieve building-wide bed bug elimination, a combination of dust bands placed on furniture legs and interceptors placed under furniture legs to reduce bed bug populations, and using pharaoh ants to control bed bugs.

Organizer: Changlu Wang, cwang@aesop.rutgers.edu, Entomology, Rutgers University, New Brunswick, NJ

1:45 26.1 Cost-effective approaches for bed bug management in multi-unit dwellings, Changlu Wang, cwang@aesop.rutgers.edu, Entomology, Rutgers University, New Brunswick, NJ

Bed bugs continue to be a significant public health pest in urban communities. As high as 25% infestation rate was found in a recent survey in New Jersey. We conducted a series field studies investigating the best IPM approaches for bed bug management. Novel cost effective methods and the effective use of the current non-chemical and chemical tools were tested in several low income communities. Results revealed that using these strategies resulted in much higher bed bug reduction than the existing management strategies. The cost and effectiveness of these bed bug IPM programs will be discussed.

2:10 26.2 Natural enemies of bed bugs: Pharaoh ants as an effective predator and a potential control agent?, Grzesiek Buczkowski, gbuczkow@purdue.edu, Entomology, Purdue University, West Lafayette, IN

The current control methods for bed bugs rely mostly on physical or chemical methods. The use of biological control agents in the form of natural enemies has not been explored. The goal of the current project was to evaluate predation on bed bugs by pharaoh ants. Results of laboratory tests and simulated field experiments demonstrate that pharaoh ants are extremely effective predators of all developmental stages bed bugs. In summary, pharaoh ants have a good potential for controlling bed bugs in residential settings, but further testing in naturally infested environments is needed.

27 • Synergizing organic and IPM

Room 155F

The presenters will draw from a collaborative white paper written by the Organic and IPM Working Group, expected publication in early 2015.

Organizers: Alisha Bower, abower@ipminstitute.org, and Thomas A Green, ipmworks@ipminstitute.org, IPM Institute of North America, Inc., Madison, WI

3:00 27.1 Setting the groundwork: Similarities, differences, and definitions for organic and IPM, and rationale for working together to tackle joint priorities, Thomas A. Green, ipmworks@ipminstitute.org, IPM Institute of North America, Inc., Madison, WI

Tom Green will introduce the Organic and IPM Working Group, its mission, and recent activities. He will also introduce key concepts, definitions, and set parameters and goals for the ensuing discussion when audience members are invited to actively participate in a productive dialogue.

3:30 27.2 Market drivers and barriers to organic adoption, Grace Gershuny, gracegershuny@gmail.com, Gaia Services, Barnet, VT

Grace Gershuny will present an overview of organic food and agriculture in the marketplace, including history, production and current trends.

4:15 27.3 Market drivers and barriers to IPM adoption, Susan Futrell, sfutrell@mchsi.com, Red Tomato, Plainville, MA

Susan Futrell will present an overview of IPM in the marketplace including history, examples and influences on IPM marketing in the United States, and facilitate discussion to identify ways to improve Organic and IPM implementation.

4:40 27.4 Organic and IPM priority setting for research, policy and education, Brian P. Baker, bpb33@cornell.edu, Independent Consultant, Ithaca, NY

Brian Baker will share observations and present recommendations on mutual priorities for organic and IPM for policy, education and research. He will give a brief update from the 2015 Organic Agriculture Research Symposium (OARS) and the Technology Innovation Platform of IFOAM, as well as draw from results of the Organic and IPM Working Group priority

ranking survey. Subsequent discussion will encourage audience members to identify additional priorities.

28 • Educating IPM practitioners: Critical component for sustainable agricultural systems

Room 155D

The effective and efficient management of pests through Integrated Pest Management (IPM) is critical to improving the sustainability of agricultural production systems. IPM practitioners must possess specialized knowledge about the pests and their management, but also must understand all aspects of the production system involved. This increased interdisciplinary requirement for IPM expertise occurs at all levels of agriculture from subsistence farming through high input and technologically driven agricultural systems found in most developed countries. This symposium will explore the educational requirements for IPM practitioners to be effective in virtually every agricultural employment situation. We will target speakers that address the importance of IPM and the need for IPM practitioners in the following professional arenas: Food industry, Multi-national seed/chemical industry, Contract research industry, Crop consultants, State/Federal agencies (USDA-APHIS-PPQ or state agency), Military needs, IPM in international agriculture (USAID or international IPM expert), Status of IPM education in the US.

Organizers: Gary L. Hein, ghein1@unl.edu, Doctor of Plant Health, University of Nebraska, Lincoln, NE; Amanda C. Hodges, achodges@ufl.edu, Doctor of Plant Medicine, University of Florida, Gainesville, FL; Norman C. Leppla, ncleppla@ufl.edu, University of Florida, Gainesville, FL

3:00 28.1 IPM, pest risk analysis and safe trade—Educational challenges for regulatory professional, Stephanie Bloem, Stephanie.Bloem@aphis.usda.gov, Center for Plant Health Science and Technology, USDA-APHIS-PPQ, Raleigh, NC

The effective and efficient management of plant pests through Integrated Pest Management (IPM) improves the sustainability of agricultural production systems and the marketability of its products both domestically and internationally. Expertise in IPM is critical to professionals involved in all aspects of agriculture. This includes regulatory professionals who are tasked with protecting the United States from the risks of entry, establishment and spread of plant pests while also promoting agricultural exports for its growers and producers. This presentation will summarize the educational challenges faced by the chain of government professionals involved in the international agricultural import and export trade continuum.

3:15 28.2 IPM challenges in crop consulting, Billy M. McLawhorn, Jr., bmclawhorn@mcsiag.com, McLawhorn Crop Services, Inc., Cove City, NC

Historically, many crop consultants worked within a single discipline, such as Entomology. But in recent years, the vast majority of consultants are much more likely to be involved with all aspects of soil and crop management. They generally work with growers who are among the most progressive, best-educated, and most demanding. Interdisciplinary continuing education is essential to the success of the consultant and his clientele, as new technologies involving bio-engineered crops and tools of precision agriculture are rapidly adopted. Yet, at a time when Applied Research at our Land Grants is needed worse than ever, those programs are receiving fewer resources

3:30 28.3 Sustainability and IPM from a food distributor's perspective—What customers are interested in learning about agricultural practices, Georgiann Miller, Miller.Georgiann@corp.sysco.com, Sysco, Houston, TX

Sysco is the global leader in selling, marketing and distributing food products to restaurants, healthcare and educational facilities, lodging establishments and other customers who prepare meals away from home. Its family of products also includes equipment and supplies for the foodservice and hospitality industries. The company operates 193 distribution facilities serving approximately 425,000 customers. For Fiscal Year 2013 that ended June 29, 2013, the company generated record sales of more than $44 billion. Sysco's signature programs in sustainable, responsible and safely sourced food - paired with their participation in industry efforts in the growing sustainable food movement - help them to understand their growers, ranchers, processors. That strong relationship with their industry partners facilitates Sysco's efforts to educate customers and share with the entire industry best practices to supply food products that meet high standards of safety, quality, traceability and social and environmental stewardship.

3:45 28.4 Industry perspectives on practitioner education and intern experiences, Michael Seagraves, michael.seagraves@driscolls.com, Driscolls, Watsonville, CA

Driscoll's is the leading fresh market berry company in the world and has operations on six continents. The enterprise is challenged by pests during breeding, nursery, fruit production, and post harvest. This talk outlines thoughts on the requirements for pest knowledge workers to contribute value in a fast paced environment where there is not a large body of previous work to draw upon and decisions must be made quickly with some level of uncertainty and ambiguity.

4:15 28.5 Educational needs of IPM in developing countries, Rangaswamy Muniappan, rmuni@vt.edu, IPM Innovation Lab, Virginia Tech University, Blacksburg, VA

Most developed countries are in the temperate and the developing countries are in the tropical regions. Crops and

socio-economic factors differ markedly in these regions, hence adoptive research is important in technology transfer. Developing countries need both human and institutional capacity building in IPM. Long- and short-term training are needed. Graduate training should include obtaining degrees in the US universities, sandwich programs, receiving degree in neighboring countries and the host country itself. South-South training should be encouraged in short-term training. Collaboration of US Institutions, CGIAR Centers, private institutions and NGOs in provision of training and involvement of donor agencies are important.

4:30 28.6 IPM knowledge expectations for California's licensed pest control advisors, Frank G. Zalom, fgzalom@ucdavis.edu, Department of Entomology and Nematology, University of California, Davis, CA

California law requires that anyone who offers a recommendation on any agricultural use of a pest control product or technique must be licensed by the state as a Pest Control Adviser (PCA). Licensing requirements include given levels of academic achievement and coursework, passing a licensing exam that includes questions on pesticide laws and basic principles of IPM, and continuing education. PCA licensing differs from certification by professional organizations since it is a requirement for providing consulting services rather than recognition of expertise or adherence to a code of ethics. Establishing IPM knowledge expectations for PCA licensing provides an opportunity to put higher levels of IPM into practice.

4:45 28.7 Novel education for the next generation of IPM practitioners, Amanda C. Hodges, achodges@ufl.edu, Doctor of Plant Medicine, University of Florida, Gainesville, FL; Gary L. Hein, University of Nebraska, Lincoln, NE

The Doctor of Plant Health (DPH) program at the University of Nebraska–Lincoln and Doctor of Plant Medicine (DPM) program at the University of Florida are professional doctoral-level programs that focus on providing interdisciplinary training across all aspects of plant health. These programs provide a dramatically different model for graduate education to supply professionals capable of meeting a variety of applied needs. Graduates of these professional programs, i.e. plant doctors, will help provide the knowledge intensive leadership required for incorporating IPM into sustainable plant production systems that address the challenges of the 21st Century.

5:00 28.8 Discussion, Gary L. Hein, ghein1@unl.edu, Doctor of Plant Health, University of Nebraska, Lincoln, NE

29 • New advances in school IPM

Room 155E

This session describes applied research for developing criteria and assessment tools for best school IPM practices in very different settings. Research and intervention school IPM programs in Israel were implemented with the goal of reducing pest, pesticide and other hazardous chemical exposures; while in the US school IPM is a well-recognized and supported concept. The sessions document different approaches and assessment techniques and invite the audience to share their experiences in promoting and monitoring an effective IPM approach and program.

Organizers: Megan Dunn, mdunn@pesticide.org, Northwest Center for Alternatives to Pesticides (NCAP), Everett, WA; Debby F Mir, debbymir@gmail.com, Tel-Aviv University, Tivon, Israel

3:00 29.1 Measurement of pesticide reduction in schools, Megan Dunn, mdunn@pesticide.org, Northwest Center for Alternatives to Pesticides (NCAP), Everett, WA; Sharon Selvaggio, sselvaggio@pesticide.org, Northwest Center for Alternatives to Pesticides (NCAP), Eugene, OR

This project is part of an ongoing effort to reduce pesticide use in US schools and seeks to quantify pesticide reduction and policy impact by cataloguing alternative best practices. This is a novel approach to measure the impact of pesticide alternatives utilized in IPM protocols for schools and measure the potential reduction of chemical exposure and therefore, risk reduction. The presentation will include the research and background to create the measurement and the application of these techniques. The measurement is intended to document the actual reduction of pesticide exposure risk when an IPM policy is in place.

3:25 29.2 Adapting IPM to Israel through internal and US partnerships, Debby F Mir, debbymir@gmail.com, Tel-Aviv University, Tivon, Israel; Sagi Gavriel; Shirra Freeman

This session describes progress and challenges introducing school IPM to Israel while reducing exposure to pests and hazardous chemicals. Pilot programs and materials were tested in Jewish and Arab schools and kindergartens and are under review by the ministries of Education and Environmental Protection. On-site surveys/training and workshops for seventy kindergartens assessed the potential and responsible bodies (national or local government, staff) for implementing IPM and identified conflicts with space and security needs. The annual PCP's workshop called for new policy and licensing requirements after a literature survey of school IPM in the US and elsewhere, but change is slow.

30 • IPM adoption in colleges and schools: A view of the process

Room 155E

The process to get IPM adoption takes on many forms, based on the experience, understanding, and motivation of the IPM adopter. A university might initiate a policy that the school "must follow IPM Guidelines" without knowing what IPM means or without understanding the commitment needed. The California Healthy Schools Act (HSA) put into code DPR's school and child care IPM programs by funding a voluntary IPM program relying on information and training to bring about adoption. Barriers to IPM adoption will be discussed in practical terms and with reference to a series of experiences and surveys.

Organizers: George G. Bernardon, george.bernardon@sscserv.com, Grounds Management, SSC Service Solutions, Knoxville, TN; Thomas A. Babb, thomas.babb@cdpr.ca.gov, Pest Management and Licensing Branch, California Department of Pesticide Regulation (California EPA), Sacramento, CA

4:15 30.1 IPM management for a large college campus setting, George G. Bernardon, george.bernardon@sscserv.com, Grounds Management, SSC Service Solutions, Knoxville, TN

We started a contract with a university that has an enrollment of 55,000 students plus faculty. In the contract specifications it stated "must follow IPM Guidelines" - but there once on site, an IPM plan did not exist. We created and implemented. It is my intent to walk throught the process of getting faculty, student, management and employee buy in.

4:45 30.2 Creating incentives for IPM adoption in california schools and child care, Thomas A. Babb, thomas.babb@cdpr.ca.gov, Pest Management and Licensing Branch, California Department of Pesticide Regulation (California EPA), Sacramento, CA

The California Healthy Schools Act (HSA) put into code the Department of Pesticide Regulation's (DPR) school and child care IPM programs. These programs offer voluntary IPM training to child care centers and public school districts in a train-the-trainer format. The programs have produced training curricula, child care IPM videos, school IPM videos, pest fact sheets, a comprehensive school IPM guidebook, a child care IPM toolkit, and teacher posters on ants and IPM. Nearly 86% of 1,000 school districts have participated in a "hands-on" IPM workshop since 2002. The effectiveness of DPR's efforts was assessed by seven school district and child care surveys, beginning with a baseline school district survey in 2001. Written pest management policies increased from 40% (2002) to 55% (2010) and workshop trainees report increased use of IPM practices compared to the untrained. Ant management using soapy water, caulking, and baits has also increased since 2002. Child care center surveys in 2008 and 2013 indicate that 23% of respondents have an "environmentally friendly" pesticide policy, but only 22% have even heard of IPM. While most child care centers use pesticides, 60% use least-hazardous pesticide products. DPR continues to find innovative ways to increase adoption of least-hazardous pest management practices in schools and child care centers. These include enhancing the train-the-trainer workshops with peer-to-peer presentations, offering videos as training tools, and focusing on particularly problematic pest situations, such as turf weeds. In the future, we plan to influence pesticide use by comparing local use to statewide, area-wide, or peer use.

31 • Role of microbial control agents in IPM

Room 155A

Some successful examples of using entomopathogens for managing endemic and invasive pests of strawberries, vegetables, and orchard systems will be presented. Strategies used in developing management programs that integrate biopesticides into current IPM practices and improve pest management efficacy will be discussed. Importance of successful examples and timely outreach for increased acceptability of biopesticides in conventional agriculture will also be discussed. Examples include microbial control of various pests in Washington and California.

Organizer: Surendra K Dara, skdara@ucdavis.edu, Division of Agriculture and Natural Resources, University of California Cooperative Extension, San Luis Obispo, CA

9:45 31.1 Incorporating entomopathogenic nematodes into production systems: What needs to change and what can stay the same?, Edwin Lewis, eelewis@ucdavis.edu, Entomology and Nematology, University of California, Davis, CA

The ability to incorporate biocontrol agents into current, non-organic agricultural production systems is a necessary step toward the reduction of chemical pesticide use. Determining compatibility between biocontrol agents and agrichemicals is only part of the solution. Small changes in pesticide use, irrigation, tillage, etc., can yield a system amenable pest management using biocontrol agents. Here, I will use entomopathogenic nematodes as a test case as to what changes need to be implemented in crop management to enable and optimize their use. Success is measured in terms of efficacy, persistence and predictability of entomopathogenic nematodes.

10:05 31.2 Importance of entomopathogenic fungi in strawberry and vegetable pest management in California, Surendra K. Dara, skdara@ucdavis.edu, Division of Agriculture and Natural Resources, University of California Cooperative Extension, San Luis Obispo, CA

Microbial control especially with entomopathogenic fungi is an underexplored area in conventional strawberries and vegetables in California. Most of the pests that cause significant damage to strawberries and vegetables are susceptible to entomopathogenic fungi such as *Beauveria bassiana*, *Metarhizium brunneum*, and *Isaria fumosorosea*. Laboratory studies

evaluated the pathogenicity of these fungi against the invasive Bagrada bug (*Bagrada hilaris*). Multi-year field studies showed that microbial control can play an important role in the IPM of aphids (*Brevicoryne brassicae* and *Myzus persicae*) on broccoli, western flower thrips (*Frankliniella occidentalis*)on lettuce, lygus bug (*Lygus hesperus*) and twospotted spider mite (*Tetranychus urticae*) on strawberries. Sustainable pest management strategies can be developed by combining and rotating biopesticides with chemical pesticides.

10:25 31.3 Role of various entomopathogens in pest management in orchard systems, Lawrence Lacey, lerrylacey@yahoo.com, IP Consulting International, Yakima, WA

Microbial control agents (MCAs) are ready made components of IPM systems that allow other natural enemies to function. Control of orchard pest insects using MCAs, including viruses, *Bacillus thuringiensis*, fungi and entomopathogenic nematodes have been demonstrated in apple, pear, stone fruits, citrus and several nut crops. Bt is the most used MCA for control of lepidopteran orchard pests. Codling moth granulovirus is increasingly being used in apple and pear by organic growers and conventional growers. Although some success has been achieved, in most orchard systems MCAs account for a relatively small proportion of the pest control tactics employed.

32 • New tools for your toolbox: Manipulation of agricultural and forest pests with Specialized Pheromone & Lure Application Technologies (SPLAT®)

Room 155B

Since 2004, several formulations of SPLAT®, a unique controlled-release device useful for dispensing pheromones and other chemicals, have been developed several of which are incorporated into integrated pest management (IPM) programs throughout the word. SPLAT® formulations typically have a paste or cream-like consistency, which can be applied at any size by a variety of manual and mechanical means. The aqueous component of the SPLAT® emulsion makes its flowable, while the non-aqueous component is the controlled-release device comprised of the active ingredient(s) and additives that provide environmental protection and dictate release rates. This symposium features a technical description of how SPLAT® functions, and highlights recent research concerning developed of novel SPLAT®-based repellents, mating disruptants, and attract-and-kill agents for notable agricultural and forest pests.

Organizers: Christopher J Fettig, cfettig@fs.fed.us, USDA Forest Service, Davis, CA; Agenor Mafra-Neto, president@iscatech.com, ISCA Technologies Inc., Riverside, CA

9:45 32.1 Management of insects with semiochemicals using SPLAT® technologies, Agenor Mafra-Neto, president@iscatech.com, ISCA Technologies Inc., Riverside, CA; Rafael Borges, Brittany Poirson, Carmem Bernardi, William Urrutia, Jonathan Rico, Kim Spencer, and Rodrigo Silva, ISCA Technologies Inc.

Specialized Pheromone & Lure Application Technology (SPLAT®) is a biologically inert matrix for the sustained release of insect semiochemicals, phagostimulants, plant volatiles, biological control agents, insecticides and countless other compounds used for pest management in agricultural, urban and forest ecosystems. Semiochemicals for use in SPLAT® might be synthesized or derived from extracts of natural products. Understanding the composition and mechanism of activity of semiochemicals allows for better selection and optimization of the natural product extraction and formulation processes. SPLAT® formulations have been tailored to deliver species-specific control through a variety of mechanisms including attract & kill, mating disruption, repellency and mass trapping.

10:00 32.2 Development of specialized pheromone and lure application technologies for management of bark beetles (Coleoptera: Curculionidae) in Western North America, Christopher J. Fettig, cfettig@fs.fed.us, USDA-Forest Service, Davis, CA; A. Steven Munson, Brytten E. Steed, and Robert A. Progar, USDA Forest Service

Several tactics are available to manage bark beetle (Coleoptera: Curculionidae, Scolytinae) infestations and to reduce associated levels of tree mortality. In some cases, semiochemicals such as verbenone may be applied, but have generally received limited use due to inconsistent efficacy often associated with inadequate release and limitations in the range of inhibition observed. We describe development of SPLAT® Verb (USEPA No. 80286-20, August 2013), a novel semiochemical tool containing (–)-verbenone for protecting individual trees and forest stands from mortality attributed to mountain pine beetle. On the basis of this research, we explore development of other SPLAT®-related products for bark beetle IPM.

10:20 32.3 IPM of tropical fruit flies (Diptera: Tephritidae) with fruit fly lures and SPLAT® technologies, Roger I. Vargas, roger.vargas@ars.usda.gov, USDA-Agricultural Research Service, Hilo, HI; Luc Leblanc, Department of Plant and Environmental Protection Sciences, University of Hawaii, Honolulu, HI; Jaime Pinero, Cooperative Research and Extension, Lincoln University, Jefferson City, MO; Agenor Mafra-Neto, ISCA Technologies Inc., Riverside, CA

Fruit flies (Diptera: Tephritidae) are among the most economically important pests in the world attacking a wide range of fruits and fleshy vegetables throughout sub-tropical and tropical areas. They are such devastating pests that major control and eradication programs have been developed in various parts of the world to combat them. The arsenal of control methods consists of crop sanitation, insecticide sprays

to foliage and soil, bait-sprays, male annihilation techniques, releases of sterilized flies and biological control using parasitoids. We present an overview of tropical pest species in the genus Bactrocera and explore IPM programs that utilize multiple components to manage them.

33 • Herbicide resistance, weeds and IPM: The human dimension of how the problem evolved and how to mitigate the issues

Room 155C

While the evolution of herbicide resistance in weeds is not a new issue, wide-scale resistance to glyphosate across North and South America and wide spread multiple resistant ryegrass populations in Australia has brought a renewed focus on weed management and integrated approaches to mitigating these economically important problems. However, the questions that should be addressed are not which of a large suite of tactics should be adopted to address herbicide resistant weed problems, but why are the IPM practices largely going unused and what can be done to facilitate the use of these effective tactics. These questions require that the human dimension of agricultural decision making be addressed; given that the socio-economic dynamics of agriculture has changed dramatically in the last two decades and that these dynamics were largely influenced by the adoption of genetically engineered technologies, what can be done to influence better weed management decisions based on IPM principles? The symposium will review the history of weed management, available tactics and how agriculture got where it currently rests. The reasons growers make decisions will be discussed and available options reported. The implications of time management-based considerations and the economics of pest management will be described. The role of incentives and increased regulations will be suggested. Finally, the rationale to address weed management and the evolution of herbicide resistant weeds as a common community issue will be developed.

Organizer: Micheal D.K. Owen, mdowen@iastate.edu, Agronomy Department, Iowa State University, Ames, IA

9:45 33.1 Perspectives of herbicide resistant weeds in agriculture and the need for greater management diversity, Micheal D.K. Owen, mdowen@iastate.edu, Agromomy Department, Iowa State University, Ames, IA

Herbicide resistance in weeds has been a problem for many decades. Recent recognition of widespread glyphosate resistance has resulted in considerable discussion and concern at many levels. The Weed Science Society of America in conjunction with the National Academies of Sciences convened several meetings which brought to the table a number of federal agencies and resulted in a statement by the Secretary of Agriculture describing the importance of weed management and the need for a diversity of tactics. While herbicides will remain a key tactic for weed management, the use of mechanical, cultural and biological tactics should also be considered.

10:15 33.2 Economics of herbicide resistance management, George B. Frisvold, frisvold@ag.arizona.edu, University of Arizona, Tuscon, AZ

Three factors complicate management of herbicide resistant weeds. First, weed management decisions depend on their effects on overall household income and well-being in addition to per-acre profits. Second, while the costs of resistance management accrue in the short-run are more certain, benefits accrue in the long run and are more uncertain. Third, benefits may depend on whether neighbors also manage resistance, increasing uncertainty further. Despite these complications, economics can identify cases where resistance management "pays for itself" in just a few years. Where benefits take longer to accrue, additional economic incentives may be needed to encourage resistance management.

11:00 33.3 Community-based approaches for common pool resource challenges in herbicide resistance management, David Ervin, dervin@pdx.edu, Portland State University, Portland, OR

If herbicide resistance is mobile across farms, herbicide-resistant weeds is a resource shared by the community, i.e., a common pool resource. A farmer's attempts to control the spread of resistance will be limited as they have no assurance their neighbors will do the same. There are three stereotypical approaches to managing common pool resources: (1) government regulation: (2) public or private incentive schemes, and (3) community-based approaches led by growers and with possible assistance from industry and government. The final approach has the advantage that growers actively design and implement the management program, which can lower costs and enhance efficacy.

11:30 33.4 Removing barriers to weed management diversification by highlighting the hidden costs of biological time constraints, Jeffrey L. Gunsolus, gunso001@umn.edu, University of Minnesota, St. Paul, MN

Periodicity of weed emergence, rate of weed growth, and crop sensitivity to weed competition are time-dependent properties that influence weed management. Postemergence tactics allow farmers to decouple the time constraints of tillage and soil-applied herbicide application from planting date. However, without a diversified weed management strategy, this tactic has led to the development of weed species that are resistant to multiple herbicide mechanisms of action. This presentation will explore the influence that biological time constraints have on profitability and describe educational methodologies that expose these hidden costs to farmers, removing some of the barriers to diversification of weed management.

34 • Pollinator protection: The role of IPM

Room 155D

Pollinator protection is a major issue in agriculture today. About 1/3 of US food production is dependent on effective insect pollination, whether by contracted beehives or by native pollinators. The number of managed honey bee colonies has dropped from approximately 6 million in 1947 to 2.5 million in 2012. At the same time, the demand for managed pollinators continues to rise; for example, acres of planted almonds have risen from 550,000 in 2004 to 800,000 in 2013, requiring about 1.6 million honey bee colonies. In June 2014, President Obama signed an exective memorandum entitled, "Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators," directing federal agencies to collaborate on this issue through the Pollinator Health Task Force. This panel discussion includes 1) an update from the Task Force (if available); 2) the regulatory actions on pesticides acutely toxic to bees; 3) projects and practices in place to protect pollinators on DOD-managed land; 4) research on agricultural practices to bolster native pollinators; 5) examples of crop-specific IPM practices that protect pollinators; and 6) the development of managed pollinator protection plans at the state and local level to advance these practices.

Organizer: Denise T. DeBusk, denise.debusk@navy.mil, Naval Facilities Engineering Command, Atlantic, Norfolk, VA

9:45 34.1 Pollinator protection: Regulatory actions and voluntary approaches, Thomas F. Moriarty, moriarty.thomas@epa.gov, Office of Pesticide Programs, US Environmental Proection Agency, Washington, DC

US EPA co-chairs (with USDA) the Pollinator Health Task Force; in December 2014, the Task Force delivered the National Pollinator Health Strategy to the White House. Using its authority under FIFRA, US EPA has implemented label changes on products containing four widely used neonicotinoid ingredients, and is planning comparable actions for other classes of pesticides acutely toxic to honey bees and other insect pollinators. US EPA is also working with state agencies to develop local strategies to further protect managed pollinators, especially those managed by hobbyists or commercial bee keepers that are not used for contracted pollination.

10:05 34.2 Pollinator protection through enhanced landscapes and outreach in the Department of Defense, Denise T. DeBusk, denise.debusk@navy.mil, Naval Facilities Engineering Command, Atlantic, Norfolk, VA

The US Department of Defense (DOD) manages approximately 29 million acres of land. These lands encompass a wide variety of habitats, and healthy landscapes are vital to carrying out the military mission. Pollinators are essential to keeping landscapes healthy. Restoring natural plant communities and controlling invasive species can protect imperiled pollinators and save money. DOD lands present opportunities to restore habitats for pollinators, and contribute to plant diversity and food security. Several projects where natural and managed landscapes were enhanced to protect pollinators and outreach techniques to encourage best management practices will be discussed.

10:25 34.3 Enhancing pollinator habitat in agricultural landscapes, Jaret C. Daniels, jdaniels@flmnh.ufl.edu, Florida Museum of Natural History, Gainesville, FL

Populations of managed and wild insect pollinators have suffered declines in recent years prompting calls for proactive strategies designed to bolster native pollinators and increase the sustainability of the valuable ecosystem service they deliver in agricultural systems. Provision of pollinator habitat in proximity to cropped areas is an appealing conservation approach because it offers the potential benefits of biodiversity conservation and enhancement of biological control of pests and pollination service. Several research initiatives addressing on-farm implementation of pollinator-targeted habitat enhancements will be discussed along with best-practice recommendations.

11:00 34.4 IPM strategies to protect pollinators, Julianna K. Wilson, jkwilson@msu.edu, Department of Entomology, Michigan State University, East Lansing, MI

Michigan State University Extension staff recently developed and published a set of IPM Best Management Practices to deploy in Michigan orchards pollinated by insects. Describe the process followed, including success stories and lessons learned. These BMPs are recommended in addition to measures required by pesticide product label, such as cultivar selection, scouting for pollinator activity, pesticide selection and application method, or native planting areas that support local pollinators.

11:15 34.5 State and local efforts under Managed Pollinator Protection Plans (MP3s), Scott Oldham, soldham@utah.gov, Utah Department of Agriculture and Food, Salt Lake City, UT

This presentation describes Utah's approach to engaging growers, applicators, and beekeepers to implement pollinator protection strategies for those honey bees and other pollinators that are not contracted. Some states are further along in the development of MP3s, but label mitigation may be linked to alternative measures in states with approved MP3s.

11:30 34.6 Discussion

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35 • Tools for successful IPM in schools and childcare centers: Collaborating resources for the National IPM Training Program and best management practices

Room 155E

There remains a need for succinct, yet comprehensive guidance resources and trainings for practitioners and school staff. The two presentations will address this specific challenge. Shaku Nair of the University of Arizona will present the Stop School Pests effort: A National IPM Standard Training Program. This program is designed to standardize IPM training for school professionals (administrators, nurses, facility managers, custodians, maintenance staff, grounds staff, food service staff, teachers, pest management professionals) and offer certification and recognition for their effort to learn more about their IPM role in schools. This will be followed by a presentation by Lynn Braband of the NYS Community IPM Program of Cornell University introducing the IPM Best Management Document. The purpose of this project is to provide individuals a best of the best IPM management documents available all on one website. Presentations will provide the audience with the opportunity to ask questions, discuss concerns and share ideas.

Organizers: Lynn Braband, lab45@cornell.edu, NYS Community IPM Program, Cornell University, Rochester, NY; Shaku Nair, nairs@email.arizona.edu, MAC, University of Arizona, Maricopa, AZ

9:45 35.1 Expanding school IPM Implementation within the Northeastern United States: A Best Management Practices Approach, Lynn Braband, lab45@cornell.edu, NYS Community IPM Program, Cornell University, Rochester, NY; Debra E. Marvin, NYS IPM Program, Cornell University; Edward A. Crow, retired, Maryland Department of Agriculture; Margaret Siligato, University of Rhode Island; Carol Westinghouse, Informed Green Solutions; Kathy Murray, Maine Department of Agriculture, Conservation, and Forestry; members of the Northeast School IPM Working Group

In 2013 the Northeastern IPM Center funded Expanding School IPM Implementation within the Northeastern United States: a Best Management Practices (BMP) Approach, a project of the Northeast School IPM Working Group. This project evaluated, incorporated, and augmented existing resources in the development of a school IPM best management practices (BMP) website. We piloted the website in train-the-trainer events in three states and systematically evaluated the website through surveys, focus groups, and training events.

10:15 35.2 Stop School Pests—Whole sale education efforts to kickstart a school IPM program, Shaku Nair, nairs@email.arizona.edu, MAC, University of Arizona, Maricopa, AZ; Herb Bolton, USDA—NIFA; Lynn Braband, Cornell University; Marcia Duke, National Pest Management Association; Carrie Foss, Washington State University; Lawrence 'Fudd' Graham, Auburn University; Dawn H. Gouge, University of Arizona; Tom Green, IPM Institute of North America; Janet Hurley, Texas A&M AgriLife Extension; Dave Kopec, University of Arizona; Shujuan (Lucy) Li, University of Arizona; Kathy Murray, Maine Department of Agriculture, Conservation and Forestry; Michael Page, Florida Department of Agriculture and Consumer Services; Susan T. Ratcliffe, North Central IPM Center; Gregg Smith, Salt Lake City School District; Mariel Snyder, IPM Institute; Tim Stock, Oregon State University; Kai Umeda, University of Arizona; Deborah Young, CO Coalition

The Stop School Pests Training and Certificate Project is designed to increase adoption of IPM in K-12 schools. Reducing pest and pest management related risks, by implementing a national training and certificate program for school staff. Our consortia, includes professionals from universities, non-governmental organizations, school districts, State and Federal agencies. The objective is to create a sustainable training system to increase the IPM proficiency of pesticide applicators, administrators, facility managers, custodians, teachers, and food service, maintenance, school health and grounds management staff. Our effort includes on-line training as well as in-class teaching materials and proficiency exams, which will be crowd-sourced. Stop School Pest modules will be showcased and development process discussed. An explanation of quiz/exam question creation and future plans to pilot test and host a virtual focus group will be shared with the audience. Challenges, successes and future objectives for the training program will also be discussed, along with a general outline of our Business Plan and marketing strategy.

36 • IPM Innovation Lab's IPM components and packages for tropical agriculture

Room 155F

The IPM Innovation Lab (IPM IL)— a USAID Feed the Future collaborative research support program managed by Virginia Tech—develops and implements effective IPM programs in developing countries as well as transfers technologies and scales them up. The program is centered on using evidence-based information to reduce losses due to pests, minimizing reliance on synthetic pesticides, and fostering the long-term sustainability of agricultural systems. An IPM vegetable package is a set of technologies that can include the following components: biological control; insect mating disruption; host plant resistance; grafting; bio-rational pesticides; soil amendments; and habitat management through crop rotations, intercropping, antagonistic plants or other organisms, trap

crops, roguing, and sanitation, among other practices (including chemical pesticides) . The result is a significant increase in plant health and yield, a dramatic reduction in pesticide use, and an increase in farmer income. Through this technology transfer, the IPM IL significantly contributes to improving food and livelihood security for people living in poverty throughout the world.

Organizers: Amer Fayad, afayad@vt.edu, and Rangaswamy Muniappan, rmuni@vt.edu, Office of International Research, Education, and Development (OIRED), Virginia Polytechnic Institute and State University, Blacksburg, VA

9:45 36.1 An overview of the IPM Innovation Lab, Amer Fayad and Rangaswamy Muniappan, OIRED

9:50 36.2 The role of IPM in USAID's Feed the Future Initiative, John E. Bowman, jobowman@usaid.gov, USAID Bureau for Food Security (BFS), Office of Agricultural Research & Policy (ARP), Washington, DC

The agricultural research team of USAID's Feed the Future Initiative approaches crop protection in three essential ways, 1) conventional breeding, 2) the use of genetically-engineered crops, and 3) the use of integrated pest management (IPM). In November 2014, a new five year IPM program was competitively awarded to Virginia Tech University. This talk will discuss how and why this new program differs significantly from the predecessor 10-year program. New aspects include a pre-award "e-consultation" process, reduction of focal countries, closer integration with USAID field offices, ties with sustainable intensification, and new initiatives in invasive species modelling and global climate change.

10:05 36.3 Integrated strategies for the management of *Peanut bud necrosis* virus in tomato, Naidu Rayapati, naidu.rayapati@wsu.edu, Department of Plant Pathology. Irrigated Agriculture Research & Extension Center, Washington State University, Prosser, WA

Peanut bud necrosis virus, transmitted by Thrips palmi, is a significant constraint to tomato production in subsistence agriculture in India. Due to limitations and disadvantages of chemical control of vector thrips and the lack of resistance to PBNV in cultivated tomato, the IPM IL has pursued benign IPM strategies as an alternative for managing the virus disease in farmers' fields. Raising clean tomato seedlings in nurseries and roguing of symptomatic seedlings during and soon after transplanting and implementing farmer participatory IPM tactics were found to reduce the incidence of PBNV and offer economic benefits to resource poor farmers.

10:20 36.4 Developing and evaluating vegetable integrated pest management (IPM) packages: A participatory research approach, Sulav Paudel, spaudel@idenepal.org, International Development Enterprises (iDE), Bakhundole, Lalitpur, Nepal; R. Muniappan, OIRED; E.G. Rajotte, Penn State

Rising concerns about overuse and misuse of chemical pesticides, particularly in vegetables, have brought about a renewed interest in IPM in Nepal, both from public and research sectors. Through the IPM Innovation Lab, full season IPM packages for tomato, cucumber and cauliflower were developed and evaluated during 2009-2014. IPM packages include seed/seedbed treatment using Trichoderma/Psuedomonas, soil solarisation, rouging virus infected plants, use of nylon nets in nursery, insect monitoring using pheromone traps, grafting, use of plastic trays and coco-peat, neem-based pesticides, bio-fertilizers, bio-control agents. IPM packages significantly reduce chemical pesticide use and are also economically competitive with farmer practices.

11:00 36.5 IPM for pearl millet in Niger, Malick Ba, b.malick@cgiar.org, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Niamey, Niger; R. Muniappan, OIRED; G. Norton, Virginia Polytechnic Institute and State University

The head miner (MHM) *Heliocheilus albipunctella* (de Joannis) is a chronic insect pest of pearl millet in Niger. Damage due to larvae can cause up to 85% yield loss. Augmentative biological control with releases of the parasitoid braconid wasp Habrobracon hebetor is the most promising strategy for controlling MHM. Parasitoids are released in small jute bags containing millet grains, millet flour, Corcyra cephalonica larvae and mated H. hebetor females. Parasitoids reproduce and multiply, and their offspring escape through the jute mesh and disperse to parasitize the MHM larvae in millet fields. Over 90 % parasitism of MHM larvae was achieved.

11:15 36.6 Host-free period for management of tomato leaf curl disease, Robert Gilbertson, rlgilbertson@ucdavis.edu, Department of Plant Pathology, University of California-Davis, Davis, CA

Tomato leaf curl (TLC) is an economically important disease caused by whitefly (*Bemisia tabaci*)-transmitted begomoviruses. Control is difficult and farmers often use large amounts of insecticides, with little success. These viruses are not seed- or transovarially-transmitted and have relatively narrow host ranges. This has led to the implementation of regional host-free periods, where tomatoes are not grown for 2-3 months. Disruption of the continuous cropping of tomato allows for cultivation of tomatoes under low virus pressure for 4-8 weeks following the host-free period. Two successful examples of host-free periods used in IPM packages for managing TLC will be presented.

11:30 36.7 Impact assessment of IPM Innovation Lab: Did it really generate more than $2 billion?, George Norton, gnorton@vt.edu, Department of

Agricultural Economics, Virginia Polytechnic Institute and State University, Blacksburg, VA

The results of impact assessments on the IPM IL will presented along with brief descriptions of methods used to obtain them. The usefulness and profitability of specific IPM practices in specific countries will be discussed and the overall impacts of IPM investments. Income, poverty, and environmental impacts will be highlighted and why some IPM practices provided greater returns than others. The presentation will conclude with lessons for approaches to IPM impact assessment.

11:45 36.8 Major pests and diseases of important fruit crops in Vietnam, Nguyen Van Hoa, hoavn2003@gmail.com, Southern Horticultural Research Institute, Tiengiang, Vietnam

Dragon fruit, mango, longan, and lychee are major fruit crops in Vietnam; their production contributes significantly to smallholder farmers' income. Intensive cultivation, flower manipulation for year round fruiting, climate change, and exchange/trade of planting material have led to the appearance and spread of many pests and diseases. They include: (i) Dragon fruit: fruit flies, mealybugs, stink bugs, canker, anthracnose, yellow cladode; (ii) Mango: fruit flies, leafhoppers, fruit borer, thrips, black spot anthracnose; (iii) Longan: fruit flies, witches' broom, eriophyoid mite, fruit borer, stink bug, fruit rot; (iv): Lychee: stem end borer, stink bug, downy mildew and anthracnose.

37 • The impact of pesticide exposure on indigenous cultural practitioners

Room 155A

CIBA Board Treasurer, Diania Caudell will provide a description of how traditional practitioners are frequently exposed to pesticide residue. Weavers, as an example, use their mouths to split basketry fivers. Medicinal Healers commonly collect herbs for use in their practice. Education concerning pesticide exposure and precautions is largely absent from Native communities. CIBA will meet the challenge of providing adequate education for tribal regions through the presentation of two new programs, Key to the Gate, and Old Poisons - New Problems.

Organizer: Diania Caudell, diacaudell@aol.com, California Indian Basketweavers Association, Escondido, CA

11:00 37.1 The impact of pesticide exposure on indigenous cultural practitioners, Diania Caudell, diacaudell@aol.com, California Indian Basketweavers Association, Escondido, CA

11:45 37.2 Discussion

38 • Invasive plant management: An IPM approach

Room 155B

Non-native invasive plants are a concern because they establish easily and grow aggressively, disperse over wide areas, displace native species, and reduce biological diversity. These plants invade not only terrestrial habitats but aquatic environments as well, where they can grow and proliferate undetected for many years. Management efforts for invasive plants are increasing in many areas of the US as populations of the invasives accelerate. Integrated Pest Management (IPM) methods can be used to manage invasive plants in natural and managed landscapes. IPM technologies include the use of biological, mechanical, cultural, and chemical controls.

Organizer: Donna Ellis, donna.ellis@uconn.edu, Department of Plant Science & Landscape Architecture, University of Connecticut, Storrs, CT

11:00 38.1 Integrated management of invasive mile-a-minute vines in the eastern US, Donna Ellis, donna.ellis@uconn.edu, Department of Plant Science & Landscape Architecture, University of Connecticut, Storrs, CT

IPM approaches can be implemented for many species of invasive plants, including mile-a-minute weed (*Persicaria perfoliata*), a highly invasive annual found in 13 eastern US states. Since it was first confirmed in Connecticut in 1997, mile-a-minute has spread to at least 41 municipalities in the state. It outcompetes and outgrows native species, causing ecological and economic harm. The vines can form dense mats interfering with forest regeneration and seedling establishment. 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 following its release in the US. The integrated management of mile-a-minute weed is a collaborative effort between the University of Connecticut and the Connecticut Agricultural Experiment Station, and it involves multiple partnerships with local, state, regional, and federal stakeholders.

11:30 38.2 Development of the first biological control agent of invasive swallow-worts: *Hypena opulenta*, Lisa Tewksbury, lisat@mail.uri.edu, Department of Plant Sciences, University of Rhode Island Biocontrol Laboratory, Kingston, RI

Invasive swallow-worts are one of the more destructive invasive weed species in the Northeast. Since 2005 the University of Rhode Island has conducted research on potential biological control agents for swallow-wort species. Research on biology and host range of *Hypena opulenta* was completed in 2011, and in 2013 we received approval for release of *H. opulenta* from the Technical Advisory Group (TAG) for biological control of weeds. We are currently awaiting a permit for release from USDA APHIS PPQ.

39 • Tools for successful IPM in schools and childcare centers: Measuring and evaluating verifiable school IPM

Room 155E

Educators of IPM know that measuring the success of IPM programs are difficult, this session will cover some ways to help implementers of school and childcare IPM programs measure the success of their IPM program. TurningPoint is a software package for developing and running a student classroom response system (CRS). Dr. L.C. "Fudd" Graham of Auburn University will present on the advantages of the software and how it can be implemented for IPM in schools. Dr. Graham will cover how you can measure baseline knowledge and understanding metrics while educating your audience be adults or children. One of the key parts of IPM in urban settings is inspections, Texas A&M AgriLife Extension developed a IPM Risk Calculator that measures a buildings overall "health" and gives it graded score for risk levels against 18 common pests. The calculator also informs the end user on what items are critical to repair or change to help reduce their pest risk and raise the overall building score. Ms. Janet Hurley, Texas A&M AgriLife Extension Service will cover this short session on www.ipmcalculator.com . To round out this session, the iSchool Pest Manager website and mobile App are being developed to assist schools and institutions who are trying to develop and maintain their IPM program. These resources will be a convergence of information from around the country and will feature some of the best documents to help record, track, train and measure individual IPM programs. Ms. Kaci Buhl, Oregon State University will preview some of the features of the iSchool Pest Manager resource pages.

Organizer: Janet Hurley, ja-hurley@tamu.edu, Texas A&M AgriLife Extension Service, Dallas, TX

11:00 39.1 Using TurningPoint to engage your audience and measure knowledge, L.C. Fudd Graham, grahalc@auburn.edu, Auburn University, Auburn, AL

One of the best ways to engage an audience is to get them to answer questions. With TurningPoint software, a classroom response system, you can keep your audience engaged while finding out what they know. Most members will not raise their hands to answer, but they will mash a button to select an answer from the screen. This activity keeps them involved in your presentation and allows them to interact by discussing answers. These answers can be recorded to determine the knowledge level of your audience. The software can also be used for pre- and post-tests.

11:15 39.2 Quantifying pests risks using The ipmcalculator.com, Janet Hurley, ja-hurley@tamu.edu, Texas A&M AgriLife Extension Service, Dallas, TX

Most everyone knows that the foundation of a good IPM program is inspections; however, in schools and buildings, explaining those outcomes of inspections is not easily translated. For the past decade AgriLife Extension has worked on developing a software tool to help with tracking the inspection, while at the same time showing scores that can translate to everyone. What to grab a principal's attention, tell them their campus received a D or an F. This tool is designed to assist the IPM practitioner by ranking the building and its current problems and making recommendations to assist in raising the score.

11:30 39.3 A national IPM resource inventory: iSchool Pest Manager, Kaci Buhl, buhlk@ace.orst.edu, Oregon State University, Corvallis, OR

"Do we need to create a management plan for carpet beetles from scratch? Surely someone has one, somewhere…." This project will provide an authoritative answer to that question, on your mobile device or in your office. We're building an exhaustive inventory of school IPM resources in the United States, including fact sheets, action plans, sample forms and policies. We're identifying local experts and key resources for the practitioner's toolbox. We will invite ideas from practitioners, funders, and administrators in attendance. How can we make the iSchool pest manager your new favorite hub for school IPM resources?

40 • eTools—Decision support for New York State growers

Room 155A

Many extension and IPM programs across the country are faced with delivering information to growers and IPM practitioners across large geographical areas in a timely manner to allow the implementation of the latest research-based strategies. The New York State IPM Program has developed and implemented a number of eTools that provide access to the information required to make informed pest management decisions in orchards, vineyards, processing vegetable fields, as well as greenhouses and nurseries. This session will provide four examples of eTools that are currently in use in New York State ranging from a weather network web site that delivers daily email summaries of IPM and crop forecast models, Moodle courses, a Greenhouse IPM App, interactive Pest Management Guidelines, and statewide monitoring of spotted wing drosophila via blog. This session considers all commodity areas. Many, if not all, of the ideas that will be presented have been, or have the potential to be, implemented in any commodity as well as anywhere across the United States and the world.

Organizer: Tim Weigle, thw4@cornell.edu, NYS IPM Program, Cornell University, Portland, NY

1:45 40.1 Delivery of weather and pest information via eNEWA, Tim Weigle, thw4@cornell.edu, NYS IPM Program, Cornell University, Portland, NY; Juliet Carroll

The Network for Environment and Weather Applications has a plethora of weather and pest model information available on its website (http://newa.cornell.edu). In order for this information to be most effectively implemented into an agricultural IPM strategy, it should be accessed on a daily basis. Surveys indicated that there was a disconnect between a grower's knowledge of the weather and pest information being available and the accessing of that information. eNEWA-grapes, a daily email alert, was developed and beta tested in 2014 to deliver weather and pest model information specific to the weather stations specified by the recipient.

2:00 40.2 Online IPM courses for PAT credits, Abby Seaman, ajs32@cornell.edu, NYS IPM Program, Cornell University, Geneva, NY

The NYS IPM Program has partnered with Cornell's Pesticide Management and Education Program to create and administer a series of educational modules that provide IPM education while offering pesticide applicator training credits. The modules were developed using Moodle open source course development software, which allows us to track learning via pre and post-test scores. Over 30 modules are currently available, with more being developed, providing recertification credits from ten Northeast and mid-Atlantic states. http://pmepcourses.cce.cornell.edu

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2:15 40.3 Greenhouse Scout—An interactive app for scouting and biological control information, Elizabeth Lamb, eml38@cornell.edu, NYS IPM Program, Cornell University, Ithaca, NY

In order for biological control of greenhouse insect pests to be successful a grower needs a good IPM program and lots of information. The Greenhouse Scout app was developed to provide a reference on insect pests and the beneficials that can be used to manage them that can be accessed on a smartphone, which most growers already have. To encourage efficient monitoring, it is paried with a program that allows growers to enter scouting data directly into the smartphone and view scouting results over time.

2:30 40.4 Instantaneous mapping and blog alerts for spotted wing drosophila catches, Juliet Carroll, jec3@cornell.edu, NYS IPM Program, Cornell University, Geneva, NY

In New York, a coordinated approach to deliver spotted wing drosophila (SWD) information to fruit growers has been implemented by 18 Cornell University and Cornell Cooperative Extension scientists. The Eastern SWD Volunteer Monitoring Network mapping system, www.eddmaps.org/swd/, ingests data from over 100 SWD trap sites to generate a distribution map for first trap catch. Monitoring reports posted to the SWD blog, blogs.cornell.edu/swd1/, with over 150 subscribers, provide early warning of SWD arrival. The SWD trap network has successfully informed growers about first trap catch of SWD and may provide early warning of SWD presence for at-risk fruit crops.

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41 • Protecting Mother Earth through tribal IPM and invasive species control: Preserving forests, foods, and traditional tribal cultural activities

Room 155B

This session presents three complementary approaches to Tribal IPM and Invasive Species Control issues. First, the Tribal Pesticide Program Council (TPPC) was established with support of the EPA to provide an opportunity for Native American Tribes to communicate Tribal pesticides issues to EPA, and to serve as a resource for other Tribes with pesticide issues and concerns. This presentation will include perspectives on Indigenous knowledge related to invasive species management and Tribal IPM activities, drawing on the experience of the TPPC. It will also provide an overview of current and planned TPPC efforts to promote invasive species IPM, including workshops and educational outreach activities. Second, the Western Region Tribal IPM Work Group is a multi-tribal/multi-agency work group formed to enhance communication between tribes, researchers, government entities and others on invasive pests that are negatively impacting natural resources. Its mission is to protect tribal natural and cultural resources through mutual understanding. This session will provide an overview of the Work Group's model of communication and collaboration, as well as a discussion of projects tribes and tribal people are embarking upon to protect their vital natural and cultural resources for use by future generations. Finally, a Native American IPM/Invasive Species Management working group is identifying pest/invasive species management strategies through a comprehensive and coordinated strategic roadmap. This session will present data from a 2014 survey of tribal stakeholders, and a draft of a strategic roadmap, including perceived barriers and opportunities, needs and priorities, and recommendations for future initiatives.

Organizers: Fred Corey, fcorey@micmac-nsn.gov, Aroostook Band of Micmacs, Presque Isle, ME; Nina Hapner, nina@stewartspoint.org, Kashia Band of Pomo Indians, Stewarts Point Rancheria, Santa Rosa, CA; John Phillips, jphillips@aihec.org, First Americans Land Grant Consortium, Watkinsville, GA

1:45 41.1 Tribal IPM approaches to controlling invasive species, protecting mother earth, and preserving traditional tribal cultural activities, Fred Corey, fcorey@micmac-nsn.gov, Aroostook Band of Micmacs, Presque Isle, ME

Tribal IPM programs provide an excellent example of how indigenous knowledge can be blended with modern western science for the implementation of highly successful and innovative Tribal pesticide programs. Tribal invasive species

management is a particularly relevant example of the blend of indigenous knowledge and western science because it utilizes a knowledge of the biology and ecology of pests, and knowledge of modern agricultural and forestry practices to enable a reduction in the use of pesticides necessary to control pests. Over the course of millennia, Tribes have experienced and adapted to many changes on the landscape. With the recent pronounced onset of climate change, Tribes are experiencing new challenges with invasive species, and are utilizing IPM practices to manage the distribution of invasive species which seriously impact native and resident species upon which Tribal cultural lifeways depend. This presentation will include perspectives on Indigenous knowledge as related to invasive species management and Tribal integrated pest management (IPM) activities, drawing on the experience of the Tribal Pesticide Program Council. In 2000 the Tribal Pesticide Program Council (TPPC) was established with support of the US Environmental Protection Agency (EPA) to provide an opportunity for Native American Tribes to communicate Tribal pesticides issues to EPA, and to serve as a resource for other Tribes with pesticide issues and concerns. This presentation will also provide an overview of current and planned TPPC efforts to promote invasive species IPM, including workshops and educational outreach activities.

2:15 41.2 Tribal IPM for forests and food, Nina Hapner, nina@stewartspoint.org, Kashia Band of Pomo Indians, Stewarts Point Rancheria, Santa Rosa, CA

The Western Region Tribal IPM Work Group is a multi-tribal/multi-agency work group formed to enhance communication between tribes, researchers, government entities and others on invasive pests that are negatively impacting natural resources. Our mission is to protect tribal natural and cultural resources through mutual understanding. Invasive species are damaging resources that are culturally relevant to tribes, resources that are a vital component of native culture and way of life—foods, medicines, and materials for baskets and ceremonies. Protecting these resources and ensuring their perpetuation is vital to the cultural integrity of tribal communities. As governments work to protect these resources from invasive pests, so do tribes on their tribal lands - invasive pests do not recognize boundary lines. We must work cooperatively to adequately understand how these pests move, find management solutions that minimize impacts, and ultimately preserve native natural resources. Projects conducted thus far address reducing pesticide risk for wildland-gathered food, improving forest health, and minimizing the impact of invasive species to culturally important resources. This session will provide an overview of the Work Group's model of communication and collaboration, as well as a discussion of projects tribes and tribal people are embarking upon to protect their vital natural and cultural resources for use by future generations.

3:00 41.3 Native American IPM and invasive species management strategic roadmap, John Phillips, jphillips@aihec.org, First Americans Land Grant Consortium, Watkinsville, GA, and Virgil Dupuis, virgil_dupuis@skc.edu, Salish Kootenai College, Pablo, MT

American Indian tribal lands support diverse ecosystems where pest/invasive species management issues are varied and wide-ranging. The impact of pest/invasive species infestations hits especially hard on Native American populations. The reduction in native plants means the loss of medicinal plants, cultural materials, and indigenous knowledge which are used in traditional and cultural practices. Many American Indians reside in rural areas with greater exposure to agricultural pesticides and herbicides, and they generally have larger families, less health insurance, and poverty levels nearly twice that of the US population. Thus, Indian country has greater vulnerability to pest/invasive species infestations, and less resources with which to respond effectively. As important as tribal pest/invasive species issues are, there is no comprehensive and coordinated approach to addressing them. Jurisdictional issues unique to tribes make managing environmental issues more complex. Many tribes have limited staff, funding, and equipment to devote to pest/invasive species activities, and face difficulties hiring and retaining qualified personnel, as well as maintaining accurate data. There are local, tribal, state, federal, private and non-profit institutions that are separately involved in tribal pest/invasive species issues, and each entity has its own priorities and constraints, with no overarching coordination. A Native American Integrated Pest Management/Invasive Species Management working group is identifying pest/invasive species management strategies through a comprehensive and coordinated strategic roadmap. This session will present data from a 2014 survey of tribal stakeholders, and a draft of a strategic roadmap, including perceived barriers and opportunities, needs and priorities, and recommendations for future initiatives.

3:30 41.4 Discussion

42 • Agronomic and economic benefits of seed treatments: The IPM perspective

Room 155C

Significant changes in crop production practices over the last 20 years include the adoption of GM traits, seed treatment technology, conservation tillage practices, and more postemergence herbicide options. Once a field has been planted, soil insects and crop diseases can be more difficult to manage. Replanting is very costly, and a delay in planting has a significant negative impact on crop yield. Feeding a growing world population demands ever higher yields from existing production areas. In modern US agriculture, growers use new technologies and innovations to help them face this challenge in a

sustainable way. The use of seed treatment is increasing rapidly throughout the world. Application of precise amounts of crop protection products directly on the seed provides a superior level of pest protection and resulting growth enhancement. Seed treatments can be an integral part of Integrated Pest Management, defined as "… a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks." (7 USC §136r-1) Additional advantages include ease of use, precise placement of pesticides in the root zone of the growing plant, and immediate crop protection effects after planting. Without the use of seed treatments, current farming practices would be considerably less sustainable and economical. The mini-symposium will cover agronomic and economic benefits of seed treatments on different crops, adoption of and changes to seed-applied pesticides during crop establishment, and advantages of seed treatment over other control practices in today's US agriculture.

Organizers: Ray McAllister, ray@croplife.us, CropLife America, Washington, DC, and Palle Pedersen, palle.pedersen@syngenta.com, Seedcare, Syngenta, Stanton, MN

1:45 42.1 Opening Remarks, Session Organizers

1:50 42.2 Modern IPM, David Onstad, david.onstad@pioneer.com, DuPont, Wilmington, DE

IPM is a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks. Stakeholders may include groups in society in addition to farmers and consumers. I will present the paradigm and its basic concepts. These will be related to modern tactics. Examples from the literature will be discussed.

2:05 42.3 Assessing risk and return on investment of fungicide and insecticide soybean seed treatments, Shawn Conley, spconley@wisc.edu, Department of Agronomy, University of Wisconsin, Madison, WI

Over the last decade, earlier soybean [*Glycine max* (L.) Merr.] planting, increased seed costs, and higher commodity prices have led to a surge in the use of fungicide and insecticide seed treatments across the United States. This rapid adoption of soybean seed treatments has spurned a significant and heated debate over the perceived versus actual value of these products to the grower and where these products fit into our current IPM strategies. In this session, we will discuss strategies to assess risk and quantify the return on investment to the grower of soybean fungicide and insecticide seed treatments.

2:20 42.4 Liife without neonicotinoids, John Haynes, johnhaynes84@btinternet.com, MJ & SC Collins, Harlow, Essex, UK

Establishing oilseed rape (OSR) in 2014 was far more challenging than anticipated following the revocation of neonicotinoid seed treatments; a substantial building block when planning an Integrated Pest Management programme in the UK. Growing OSR is a challenge at the best of times during the peak of harvest when resources are stretched and the soil is typically very dry. The main pest at establishment is cabbage stem flea beetle which attacks the crop from the offset. We were on the receiving end of an onslaught from the pest which resulted in severe crop damage and massive increases in growing costs.

2:35 42.5 Managing bean leaf beetles on our farm, Ray Gaesser, gasserfarms@gmail.com, Gasser Farms, Corning, IA

We grow approximately 3,000 acres of Soybeans and 3,000 acres of corn each year. My first experience with bean leaf Beetles was in 1994, we had a severe infestation in one field that resulted in high yield loss from pod mottle virus and pod clipping. Since that year we have the need to manage bean leaf beetles. We found that controlling the overwintering beetles before they laid eggs was our best practice. Before Neonicotinoid seed treatment became available we applied and over the top insecticide when the soybeans emerged. Since we began to use seed treatments we have eliminated that extra spray pass and control the beetles for the entire season, eliminating yield and seed quality loss.

3:00 42.6 Enhancing IPM with neonicotinoid seed treatments in the Mid-Southern US, Jeffrey Gore, jgore@drec.msstate.edu, Delta Research and Extension Center, Mississippi State University, Stoneville, MS; Angus Catchot, Mississippi State University; Scott Stewart, University of Tennessee; Gus Lorenz, University of Arkansas; David Kerns, Louisiana State University

Agronomic crops grown in the Mid-South are challenged by numerous insect pests annually. Effective and economical tools are critical for sustainable crop production. Neonicotinoid seed treatments are the most economical tool for managing early season pests of agronomic crops in the Mid-South. Their use has significantly reduced the total amount of insecticide active ingredient applied on a per acre basis, decreased the use of broad spectrum insecticides that are more toxic to non-target organisms, and provided excellent yield protection. Over 10 years of research results will be presented with an emphasis on yield protection in soybean, cotton and corn.

3:15 42.7 Economic benefits of neonicotinoid insecticides in the US and Canada, Paul Mitchell, pdmitchell@wisc.edu, Department of Agricultural and Applied Economics, University of Wisconsin, Madison, WI

This presentation summarizes findings from an extensive assessment of the benefits of neonicotinoid insecticides in the US and Canada. Results include estimates of the cost benefits of neonicotinoids based on farmer pesticide use and price data, yield benefits based on small plot studies, the value to farmers based on a survey, and the value to consumers based

on a market-level analysis of the social surplus. Estimates include $850 million in cost benefits to US farmers, $1.4 billion for US and Canadian farmers, $4.0 to $4.3 in US economic surplus and $150 to $275 million in Canada. Crops examined include corn, soybean, wheat, cotton, sorghum, canola, potato and tomato.

3:30 42.8 Panel discussion

43 • Reducing the threat posed by africanized honey bees to workers, wildlife, and IPM in agriculture

Room 155D

First reported established in Florida in 2005, Africanized Honey Bees (AHB) have become a serious threat to both humans and wildlife. They are threatening bird conservation projects throughout the Neotropics and the Southern United States, including a biological rodent control project in the sugarcane fields of the Everglades Agricultural Area in Southern Florida. These bees are competing with Barn Owls for their nest boxes, often excluding or killing the owls. In addition, the increasing bee population is putting cane workers in danger. Bee colonies are often agitated by vibrations caused by farm equipment and this combined with cryptic colony sites puts unaware cane workers at risk of attack. More defensive than their European counterparts. AHB swarm more frequently creating numerous feral colonies. If the colony is accidently disturbed, their highly defensive nature may result in hundreds of stings, inflicting serious injury or even death. We are testing a push-pull integrated pest management protocol to deter bees from inhabiting owl boxes by applying a bird safe insecticide, permethrin, while simultaneously attracting swarms to pheromone-baited traps. These swarm traps are highly visible and located eight feet off the ground thereby reducing conflict with sugar cane workers. The use of highly visible traps located off the ground will reduce the likelihood of workers being attacked by defensive bee colonies. This symposium will detail the history of the AHB invasion, why they are a serious threat and steps that are being taken to mitigate their impact on the beekeeping industry and native wildlife.

Organizer: Richard Raid, rnraid@ufl.edu, Plant Pathology, University of Florida, Belle Glade, FL

1:45 43.1 Use of barn owls for sustainable rodent control in Florida, an IPM program threatened by Africanized honey bees, Richard Raid, rnraid@ufl.edu, Plant Pathology, University of Florida, Belle Glade, FL

This presentation will include an introduction to the barn owl program, describing its use as sustainable IPM for rodent control, outreach/education, and value as assisting a threatened wildlife species. This will be followed by a brief introduction to the program being jeopardized by the AHB.

2:00 43.2 Africanized honey bees—History, problems, and future, William H. Kern, whk@ufl.edu, Enotomology and Nematology, University of Florida, Davie, FL

The history of africanized honey bees and the differences between them and the European subspecies in terms of behavior and biology will be discussed. The speaker will elaborate on the AHB problem in the US and describing why the AHB is a threat to workers and wildlife. A discussion worker safety programs currently being tested will be included.

2:15 43.3 A push-pull IPM method to protect cavity-nesting birds from africanized honey bees, Caroline A. Efstathion, cefstathion@ufl.edu, Enotomology and Nematology, University of Florida, Davie, FL

This presentation will describe the theory behind the push-pull method, its materials and methods, and some of our early results. We will discuss how this project is a model for conservation of endangered parrots in the neotropics and present results from pilot studies.

2:30 43.4 Living with africanized honey bees—How we are mitigating the threat, Robert F. Horsburgh, Rob.Horsburgh@freshfromflorida.com, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Jacksonville, FL

The implications of Africanized bees for the beekeeping industry will be described. We will discuss what methods are being done to mitigate their effects, genetic studies of bees in feral hives, and methods used to renovate and reclaim hives for future commercial use.

44 • Tools for successful IPM in schools and childcare centers: Improving environmental health and literacy through school IPM partnerships

Room 155E

Implementing IPM in complex systems often depends on collaborative partnerships. In schools and childcare facilities the staff, administrators, contractors, students and the community play critical roles. While many challenges faced by school IPM implementers are unique, the goals of reducing economic, environmental and human risks are shared with other IPM programs. Eliminating barriers separating facilities design and management, wellness programs and classroom instruction fosters support for IPM and extends it to the greater community. This session will include presentations about successful partnerships among agencies, organizations and coalitions working together to promote and support IPM implementation and education in schools and childcare facilities. The 'K-12 IPM Literacy Plan'—a roadmap for youth IPM education and the results of a 3-year teacher training and classroom demonstration program will be presented. This session will

also present information about the efforts of environmental health coalitions that are using IPM as a springboard to holistic healthy school programs. Coalitions established in several Midwestern states use IPM as a framework to tie sanitation, maintenance, IPM and green cleaning into a comprehensive and sustainable 'Green and Healthy School Program' that enhance the effectiveness and viability of school IPM programs. The results of a partnership between the US EPA and the US Green Building Council to advance IPM and environmental health under the rubric of "Healthy and High Performing Schools" will also be presented. The challenges and impacts of these partnerships will be discussed.

Organizer: Kathy D. Murray, kathy.murray@maine.gov, Maine Department of Agriculture, Conservation and Forestry, Augusta, ME

1:45 44.1 Improving IPM literacy among the next generation of earth's stewards, Kathy Murray, kathy.murray@maine.gov, Maine Department of Agriculture, Conservation and Forestry, Augusta, ME

The resurgence of bed bugs and frequent introductions of new exotic pests highlight the need to teach the next generation about sensible, effective approaches to pest prevention and management. Engaging youth and teachers in IPM education promotes adoption of IPM practices on school properties as well as in the home and community. IPM can be readily incorporated into science and math learning. Over 1,000 teachers and 20,000 K-12 students were introduced to IPM over a 3-year demonstration and education project spearheaded by the Northeast School IPM Working Group. Our website makes hundreds of standards-aligned lessons and other resources readily accessible.

2:02 44.2 Tools for successful IPM implementation in schools and childcares: Perspectives from Indiana and Illinois, Ruth Kerzee, rkerzee@pesticideaction.org, Midwest Pesticide Action Center, Chicago, IL; Margaret Frericks, Improving Kids Environment (IKE), Indianapolis, IN

Competing demands on school facilities staff time and attention require creative approaches for implementation of a viable IPM program. Improving Kids Environment and Midwest Pesticide Action Center both have long histories of trying to promote IPM in schools and childcares in Indiana and Illinois, respectively. Each has used varying strategies in different legislative and political environments to move these vulnerable communities to reduce pesticide exposure through the adoption of IPM. Sharing the challenges and successes of these efforts will give insight into barriers and how to overcome them when moving schools and childcare facilities towards IPM adoption and implementation.

2:14 44.3 Partnerships to promote sustainable pest management in schools through the Leadership in Energy and Environmental Design (LEED) program, Seth Dibblee, dibblee.seth@epa.gov, US Environmental Protection Agency Region 5, Chicago, IL

US EPA Region 5 is partnering with the US Green Building Council (USGBC) to advance IPM and environmental health under the rubric of "Healthy and High Performing Schools." Region 5 works with the local chapters of USGBC to include sustainable pest management in LEED certification of new and existing schools, taking advantage of their mission to have "every child in a green school in this generation."

2:26 44.4 Session wrap up and moderated discussion

45 • Can insecticide mixtures be used to better enable IPM?

Room 155F

The primary intention for the use of an insecticide mixture (tank-mix or pre-formulated mixture) is, in most cases, is to manage pests, rather than to manage resistance (IRAC International Mixture Statement). Mixtures can be successfully used to manage pests because they provide a technical advantage in the form of increasing target level of pest control or by broadening the spectrum of insects controlled. Individual components in mixtures developed for insect resistance management should meet certain criteria related to each active such as possessing high efficacy, are from differing modes of action, are not cross resistant, resistance not detected, and having similar periods of residual activity. The objective of the symposium is to understand factors which drive industry to develop insecticide mixtures, agricultural markets that embrace or conversely reject mixtures, and circumstances in which mixtures can be used for insecticide resistance management. Speakers will represent the following groups: agrochemical sector, a perennial cropping system (Tree Fruit/Nuts), a high value annual cropping system (Fruiting/Leafy Veg.), a broad-acre annual cropping system, and a viewpoint on mixtures for delaying insect resistance to insecticides. Each speaker will be asked to focus on how mixtures, if at all, can better enable the development of IPM programs.

Organizers: Melissa Willrich Siebert, mwillrichsiebert@dow.com, Crop Protection R&D, and Michael C. Shaw, mcshaw@dow.com, Global Product Development, Dow AgroSciences LLC, Indianapolis, IN

1:45 45.1 Opening Remarks

1:50 45.2 Insecticide mixtures in row crop IPM: A case study with cotton, Jeffrey Gore, jgore@drec.msstate.edu, Delta Research and Extension

Center, Mississippi State University, Stoneville, MS

Cotton is a perennial shrub grown as an annual crop. Due to its indeterminate growth, cotton flowers over several weeks making it attractive to multiple insect pests over an extended period of time. At any time from plant emergence until cutout, two or more yield limiting arthropods can be observed. This makes management difficult with some of the newer insecticides that tend to be more selective than standard insecticides like pyrethroids. Additionally, insecticide resistance is widespread in numerous pests of cotton in the Mid-South. These characteristics make cotton an ideal model for examining the utility of insecticide mixtures in IPM.

2:10 45.3 Insecticide mixtures in pest-intensive, high-value vegetable crops: Rationale and recommendations, John C. Palumbo, jpalumbo@ag.arizona.edu, Department of Entomology, Yuma Agricultural Center, University of Arizona, Yuma, AZ

Production of high-value, leafy vegetable crops in the desert valleys of Arizona is insecticide-intensive. Because the fresh market food industry has little to no tolerance for insect damage or contamination on produce, growers are essentially forced to maintain their harvested crops insect-free/cosmetically perfect. In these pest-intensive cropping systems, this is achieved primarily with mixtures of selective and broad spectrum insecticides. This presentation will provide an overview of the why growers rely on insecticide mixtures for control of key insect pests within the context of IPM programs developed for leafy vegetables. Examples of specific mixtures and use recommendations will be discussed.

2:30 45.4 Pre-mixes for tree fruit IPM: It's a tough sell, Peter W. Shearer, Peter.shearer@oregonstate.edu, Mid-Columbia Agricultural Research & Extension Center, Oregon State University, Hood River, OR

Tank-mixes are often more appropriate than pre-mixes for orchard IPM because PCAs can customize additions to the spray tank based on pest presence and need. Non-essential applications of some pre-mix ingredients may foster resistance development and impact pollinators.

3:00 45.5 Practical uses of insecticide mixtures, Caydee Savinelli, caydee.savinelli@syngenta.com, Regulatory & Stewardship, Syngenta, Greensboro, NC; Russell Slater, Syngenta

The newer classes of insecticides such as diamides, neonicotinoids, spinosyns and tetronic acid derivatives have a limited spectrum of control as well as being easier on beneficial insects. In order to control a number of different insect classes, growers are mixing the newer insecticides to obtain broad spectrum activity. In order to meet grower needs as well as to reduce complexity in label compliance, Syngenta has developed a number of insecticide mixtures. This talk will describe the advantages of insecticide mixtures, grower uses and how the mixtures fit in with both IPM and IRM considerations.

3:20 45.6 Implications of insecticide mixtures for delaying insect resistance to insecticides, Timothy J. Dennehy, timothy.dennehy@bayer.com, Global IRM Manager, Global Regulatory Affairs, Bayer Seeds, Research Triangle Park, NC

Mixtures of insecticides offer short-term benefits to farmers in many production systems. However, it has become fashionable to refer to insecticide mixtures used to control resistant pest, including those applied for this purpose to Bt crops, as 'resistance management.' I will discuss the distinction between measures used pro-actively to delay resistance versus insecticides use to meet production imperatives. The latter uses frequently offer no or limited IRM benefits. Moreover, they frequently divert attention from rectifying critical deficiencies in integrated pest management practices, especially in areas of the world where resistance problems are most severe.

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46 • How a new Working Group used synergy to fuel economic impact and increase deliverables

Room 155A

Extension and research professionals in Southeastern states formed the Southern Nursery IPM (SNIPM) Working Group to foster collaboration, thereby enhancing programming, increasing synergistic opportunities, expanding delivery of specialized expertise to growers across a region, and leveraging resources. The group is composed of entomology, horticulture, plant pathology, and weed science faculty and field staff. Topics covered will include: (1) how our stakeholders, our funding agencies, and we as co-PIs, have benefited from our synergy as a working group; (2) how funding to develop a Pest Management Strategic Plan and Crop Profile has had a multiplier effect, stimulating Extension and refereed publications, projects, and additional funding that resulted from closer association of the SNIPM Working Group members; (3) the ratio of deliverables to funding and how group synergy increased our ability to generate these deliverables; (4) use of survey results to understand, evaluate, and address challenges and opportunities for increasing nursery crop producer adoption of IPM; and (5) how mobile technology is changing pest management decision-making and how SNIPM's mobile technology-based tools (apps: IPMPro and IPMLite and iBooks: IPM for Select Deciduous Trees in Southeastern US Nursery Production and IPM for Shrubs in Southeastern US Nursery Production: Vol I) are helping growers. This session will conclude with a short Q&A session to address questions from the audience.

Organizers: Amy Fulcher, afulcher@utk.edu, Department of Plant Sciences, University of Tennessee, Knoxville, TN; Anthony V. LeBude, anthony_lebude@ncsu.edu, Department of Horticultural Science, N.C. State University, Mills Rivers, NC; Sarah A. White, swhite4@clemson.edu, School of Agricultural, Forest, & Environmental Sciences, Clemson University, Clemson, SC

3:00 46.1 Building a Working Group: Colleagues, funding, and stakeholders, Sarah A. White, swhite4@clemson.edu, School of Agricultural, Forest, & Environmental Sciences, Clemson University, Clemson, SC; A. Fulcher; A.V. LeBude; C.R. Adkins; S.K. Braman; M.R. Chappell; J.-H. Chong; J.F. Derr; W.C. Dunwell; S.D. Frank; F.A. Hale; W.E. Klingeman; G.W. Knox; M.L. Paret; J.C. Neal; N. Ward Gauthier; J.L. Williams-Woodward; A.S. Windham

Building a productive working group required attracting a group of research and extension specialists with complementary expertise, listening to stakeholders, and translating stakeholder needs into grant priorities to help solve problems. Our diverse group of specialists joined the working group to pool knowledge and information resources and to enhance service to stakeholders. Multiple deliverables ranging from smart phone apps to refereed papers have been produced. Growers have used these resources to guide IPM decisions, granting agencies have excellent return on investment, and collaborators have developed highly productive relationships with colleagues throughout the southeast.

3:07 46.2 Multiplier effect: How a pest management strategic plan creates a foundation for productivity, Amy Fulcher, afulcher@utk.edu, Department of Plant Sciences, University of Tennessee, Knoxville, TN; S.A. White; A.V. LeBude; C.R. Adkins; S.K. Braman; M.R. Chappell; J.-H. Chong; J.F. Derr; W.C. Dunwell; S.D. Frank; F.A. Hale; W.E. Klingeman; G.W. Knox; M.L. Paret; J.C. Neal; N. Ward Gauthier; J.L. Williams-Woodward; A.S. Windham

The Southern Nursery IPM (SNIPM) Working Group was awarded a Southern Region IPM Enhancement Grant in 2009 to develop a multi-state pest management strategic plan (PMSP) and crop profile (CP), outputs that originated from a focus group of nursery growers representing five states. Financial support from the grant served as a catalyst for this group that advanced productivity. The PMSP and CP provided a foundation for Extension and refereed publications, projects, and additional funding that resulted from closer association of the SNIPM Working Group members. How to "multiply" working group grants into meaningful deliverables will be discussed.

3:17 46.3 Synergistic benefits: Increasing Working Group deliverables and impact, Amy Fulcher, afulcher@utk.edu, Department of Plant Sciences, University of Tennessee, Knoxville, TN; S.A. White; A.V. LeBude; C.R. Adkins; S.K. Braman; M.R. Chappell; J.-H. Chong; J.F. Derr; W.C. Dunwell; S.D. Frank; F.A. Hale; W.E. Klingeman; G.W. Knox; M.L. Paret; J.C. Neal; N. Ward Gauthier; J.L. Williams-Woodward; A.S. Windham

The Southern Nursery IPM (SNIPM) Working Group was awarded a Southern Region IPM Enhancement Grant in 2009 to develop a multi-state pest management strategic plan (PMSP) and crop profile (CP). The initial funding has had a synergistic effect by stimulating multi-state Extension publications and spin-off research projects that resulted from closer association of the SNIPM Working Group members and greater awareness of individual expertise. A ratio of deliverables to dollars of funding will be discussed as a metric to gauge Working Group productivity and outputs. Key concepts to establishing and maintaining working group productivity will be discussed.

3:22 46.4 Maximizing Working Group potential: Using survey results to set stakeholder priorities and evaluate impact, Sarah A. White, swhite4@clemson.edu, School of Agricultural, Forest, & Environmental Sciences, Clemson University, Clemson, SC; A.V. LeBude; A. Fulcher; M.R. Chappell; C.R. Adkins; S.K. Braman; J.-H. Chong; W.C. Dunwell; S.D. Frank; F.A. Hale; W.E. Klingeman; J.C. Neal; J.L. Williams-Woodward; A.S. Windham

A critical component of submitting winning grant proposals is justification of the research proposed. We surveyed stakeholders both in-person and on-line, gathering, analyzing, and interpreting opinions to define research priorities. These priorities were foundational for funded research and extension projects over the last 5 years. We also tracked the utility of information in the outputs generated, documenting grower use and cost-savings and thus could show the impact of the work. We will discuss using survey results to set research and extension priorities and how to use outcomes to evaluate impact.

3:42 46.5 Working Group innovation fuels development of mobile technology based decision-making tools, Amy Fulcher, afulcher@utk.edu, Department of Plant Sciences, University of Tennessee, Knoxville, TN; J.-H. Chong; A.V. LeBude; S.A. White; W.E. Klingeman; C.R. Adkins; S.K. Braman; M.R. Chappell; J.F. Derr; W.C. Dunwell; S.D. Frank; F.A. Hale; Stanton Gill; J.C. Neal; Karen Rane; J.L. Williams-Woodward; A.S. Windham

Mobile technology is changing how growers manage crops, access information and make decisions about pest management. Since 2012, the Southern Nursery IPM (SNIPM) Working Group has launched mobile device applications, IPMPro and IPMLite, and iBooks, IPM for Select Deciduous Trees in Southeastern US Nursery Production and IPM for Shrubs in Southeastern US Nursery Production: Vol I), as resources for the Green Industry. How mobile technology is changing pest management decision-making and directing working group objectives, as well as how to measure impact from mobile technology-based tools will be discussed.

3:52	46.6	Question and answer session

47 • Smart, Sensible and Sustainable Approach to implementing your school IPM program (working session)

Room 155E

In EPA's efforts to continue building the business case for a successful school IPM program, we are inviting experts from State university extensions who provide educational programs and problem-solving assistance to citizens that are based on years of research and experience, school district officials who make critical decisions about sensitive issues with many variables including incorporating pest management strategies, and other leading School IPM advocates to join us in a working session. By implementing IPM, EPA has a goal to realize fewer pests, reduced pesticide applications, possible money savings and improved environmental health for the nation's most precious resource, our children . Come prepared to share your documented examples and success stories! Protecting children's health is a top priority at EPA. We recommend schools use integrated pest management (IPM) - a Smart, Sensible, and Sustainable approach to pest control. Smart because IPM creates a safer and healthier learning environment by managing pests and reducing children's exposure to pests and pesticides. Sensible since practical strategies are used to reduce sources of food, water, and shelter for pests in school buildings and grounds. Sustainable because the emphasis is on prevention that makes it an economically advantageous approach.

Organizer: Sherry Glick, glick.sherry@epa.gov, EPA/Office of Pesticide Programs, Dallas, TX

3:00	47.1	Round table discussion, facilitated by Sherry Glick, glick.sherry@epa.gov, EPA/Office of Pesticide Programs, Dallas, TX; Frank Ellis, ellis.frank@epa.gov, EPA/Office of Pesticide Programs, Washington, DC

poster abstracts

*Note: * by author name indicates presenting author*

P001 IPM in the 21st Century–Invasive pests, resistance, environmental/ consumer constraints and demand

Charles Allen ctallen@ag.tamu.edu

Texas A&M AgriLife Extension Service, Texas A&M Research and Extension Center, San Angelo, TX

Eradication programs, host plant resistance and seed treatment insecticides have changed the way crops are protected from insect pests and diseases in the United States. Since the turn of the 21st century, IPM programs have increasingly evolved from field specific, scouting and threshold centered programs which integrated cultural, biological and prescriptive chemical control; to host plant resistance and seed treatment approaches which are increasingly used on an area-wide basis. Programs and technological advances have reduced the demand for field-specific knowledge and service. This has resulted in loss of capability to conduct field specific IPM programs. Since 2000, there are fewer consultants, extension plant protection specialists and agents, aerial applicators, ground applicators and others with the knowledge and skills to scout and manage pests, diseases and weeds in agricultural crops. However, other changes—invasive pests, resistance, environmental and consumer concerns, and increasing demand for food and fiber associated with population growth—may reverse the trend toward preventive pest management used on an area-wide basis. Threats from invasive pests such as the sugarcane aphid in grain sorghum, and Old World bollworm in grain, fruit, vegetable, forage and fiber crops are poised to reinforce farmers need for field-specific, scouting based IPM systems for pest management.

P002 Evolution and impacts of the NYS IPM Weekly Field Crops Pest Report into social media

*Kenneth L. Wise, klw24@cornell.edu, and J. Keith Waldron

Cornell University, NYS Integrated Pest Management Program, NYSAES, Geneva, NY

The New York State IPM Field Crops Weekly Pest Report (WPR) provides timely pest management information to field crop producers, extension educators, and other agriculture professionals through a means of electronic/social media. This publication is a primary source of timely in-season field crops and livestock pest information throughout NYS. At least 20 issues have been published annually from April-October for the last 13 years providing clientele with weekly summaries of statewide pest and crop observations, detailed pest information and resources to help prepare clientele for potential pest risks. The WPR presents pest identification, scouting techniques and suggested IPM activities in real-time. Extension educators and crop consultants contribute local pest observations. This publication has evolved over the years from an emailed newsletter to a NYS IPM website. Recently, we have made the leap into social media. The report is currently published at the NYS IPM blog-site: http://blogs.cornell.edu/ipmwpr/#. Once published the blog is shared through our NYS IPM Field Crops Twitter and Facebook accounts and through the Cornell Field Crops list-serve. WPR articles subsequently appear in other list serves as well as extension newsletters and other publications. Subscriber evaluations indicate WPR articles may reach as many as 11,000 end-users per year since 2012. End-users consistently indicate that the report is important to their work and farm management issues.

P003 Communicating sustainable potato production—A North America potato industry collaboration

*Eric Ritchie[1], eric.ritchie@mccain.com, Monte Anderson[2], Richard Burres[3], Dwayne McNeill[4], John Keeling[5], Joe Brennan[6], Tom Green[7], and Patrick Shannon-Hughes[7]

[1]McCain Foods (Canada), Florenceville, NB, Canada; [2]J. R. Simplot, Caldwell, ID; [3]ConAgra Foods, Kennewick, WA; [4]Cavendish Farms, New Annan, PE, Canada; [5]National Potato Council, Washington, DC; [6]Canadian Potato Council, Johnville, NB, Canada; [7]IPM Institute of North America, Madison, WI

Responding to market place inquires for information regarding potato production practices; industry representatives joined together in 2010 and developed the Potato Integrated Pest Management (IPM) Survey. Founding participants included McCain Foods, Lamb Weston, Simplot, the National Potato Council, the Canadian Horticulture Council, several grower representatives, the IPM Institute of North America and McDonalds. The web based survey allowed growers to once yearly answer a detailed series of questions about beneficial IPM practices on their farm. Each practice was categorized as Basic, Steward, Expert, or Master reflecting a

low-management to high-management level of implementation. Participating growers were able to benchmark their farm performance, practice by practice, to the average for their region, country or market segment (i.e., frozen, chip, fresh and seed). Building on the success of the Potato IPM Survey, industry representatives began to retool the survey in 2013 to reflect the broader themes of environmental stewardship, economic wellbeing and community support. Additional industry participation was solicited and H.J. Heinz/Ore-Ida Foods, Cavendish Farms and Basic American Foods became members. A consolidated set of questions and improved user functionality was rolled-out across North America in late 2014 as the Potato Sustainability Initiative (PSI) Survey. Moving forward the survey will implement metrics to complement the practice based question survey. Metrics will measure nutrient use efficiency, water usage, waste reduction, worker health and safety, pesticide usage and greenhouse gas/energy efficiency. Survey response validation by food companies is scheduled for late 2015 and third party auditing is to begin in 2016.

P004 North Dakota wheat IPM survey: Ten-year review

*J. Knodel[1], janet.knodel@ndsu.edu, A. Friskop[1], S. Markell[1], G. Endres[1], L. Lubenow[1], V. Chapara[1], C. Hill[1], P. Beauzay[1], C. Larson[2], and S. Brunner[2]

[1]North Dakota State University Extension Service, Fargo, ND; [2]North Dakota Department of Agriculture, Bismarck, ND

Crop scouts are hired annually to survey hard red spring wheat, *Triticum aestivum* L., fields in North Dakota for major diseases, insects, and invasive pests. Approximately 2 million hectares are surveyed in 53 counties in North Dakota each year. Major diseases include: tan spot, Fusarium head blight (scab), leaf rust, Septoria species complex, and loose smut. Major insect pests include: cereal grain aphids, grasshoppers, wheat stem maggot, wheat stem sawfly and cereal leaf beetle. Several invasive diseases/pests are also surveyed for including: dwarf bunt, flag smut, new races of black stem rust and cereal leaf beetle. Pest data is mapped weekly to show the geographical distribution and severity of pests. IPM information is provided to wheat producers and other stake holders through the NDSU Extension Service Crop and Pest Report, Crop and Pest Report Facebook, the NDSU IPM Website, the AgDakota list serve, and county Ag Alerts to help growers make timely pest management decisions. From 2005 to 2014, about 10,000 fields were scouted throughout the state. Diseases and insect pests varied by years, but the most common disease was tan spot and the most common insect was grasshoppers.

P005 Implementing IPM in autumn-sown wheat in New Zealand using a participatory approach

*Abie Horrocks[1], abie.horrocks@plantandfood.co.nz, Paul A. Horne[2], and Melanie M. Davidson[3]

[1]The New Zealand Institute for Plant & Food Research Limited, Sustainable Productions, Christchurch, New Zealand; [2]IPM Technologies Pty Ltd, Victoria, Australia; [3]The New Zealand Institute for Plant & Food Research Limited, Bioprotection, Christchurch, New Zealand

Six crops of autumn-sown wheat managed under integrated pest management (IPM) were compared to six adjacent crops grown under the participating farmers' current pest management practices in farmer participatory demonstration trials in Canterbury during the 2008-09 and 2009-10 seasons. The presence and abundance of key pests and diseases (slugs, aphids, yellow dwarf virus (YDV)) and beneficial predators were determined. Carabid beetles and other beneficial insects capable of contributing to pest control were present in the arable cropping systems. There was an increasing trend in the number of beneficial organisms, a reduction in pests and a 50% reduction in the number of insecticides applied in the IPM-managed crops. There were negligible YDV and crop yield differences between the two approaches. Farmer training with a focus on monitoring and beneficial predator identification was carried out. The farmers underwent a change in practice from a routine broad-spectrum spray programme to an IPM approach aimed at maximising the use of beneficial predators whilst minimising pesticide use. The collaborative and participatory approach taken was a key factor contributing to this shift in pest management.

P006 Impact of integrative crop and livestock production on pest and beneficial arthropods

*Julie A. Peterson, julie.peterson@unl.edu, Kayla A. Mollet, Timothy M. Shaver, and L. Aaron Stalker

West Central Research & Extension Center, University of Nebraska-Lincoln, North Platte, NE

Both corn grain production and forage-based beef production are major industries in the Western US Corn Belt. The amount of forage available for grazing and haying has declined in the last decade, leading to a greater need for nutritious forage for livestock. In Nebraska, many growers have adopted the practice of grazing their cattle herds on the corn stalks that remain in their crop fields post-harvest. Cattle will remain feeding and living in these corn fields until the spring. This practice is an alternative to baling or otherwise mechanically removing corn residue. Winter grazing by cattle in a crop field could have implications for soil-dwelling and epigeal arthropods by impacting plant residue, soil health, and nutrient cycling. Therefore, we monitored beneficial arthropods and corn pests during a field study in 2014 that compared the following treatments: 1) no corn residue removal, 2) complete residue removal due to baling, 3) low intensity winter grazing by cattle, and 4) high intensity winter grazing by cattle. Beneficial epigeal arthropods were collected throughout the season using pitfall traps. Single-plant emergence cages were used to

quantify adult emergence of western corn rootworm beetles. Epigeal predators (primarily ground beetles and spiders) had higher activity-densities with no residue removal and grazing treatments compared to the baled treatment. Rootworm beetle emergence was marginally lower in the two grazing treatments. These types of integrative systems that seek to maximize the sustainable production of both crops and livestock could provide benefits to agricultural productivity.

P007 Survey of bees and syrphid flies associated with flowering soybean in the midwestern United States

Christian Krupke[1], *Patrick Beauzay[2], patrick.beauzay@ndsu.edu, Thelma Heidel-Baker[3], Janet Knodel[2], Ebony Murrell[4], Bruce Potter[5], Karly Regan[6], Ada Szczepaniec[6], and Kelley Tilmon[6]

[1]Department of Entomology, Purdue University, West Lafayette, IN; [2]Department of Plant Pathology, North Dakota State University, Fargo, ND; [3]Department of Entomology, Iowa State University, Ames, IA; [4]Department of Entomology, University of Wisconsin-Madison, Madison, WI; [5]Department of Entomology, University of Minnesota Southwest Research and Outreach Center, Lamberton, MN; [6]Department of Plant Science, South Dakota State University, Brookings, SD

Soybean [*Glycine max* (L.) Merr.] fields in six midwestern states (Indiana, Iowa, Minnesota, North Dakota, South Dakota and Wisconsin) were surveyed at peak flowering (i.e. the R2 growth stage) for bees (Hymenoptera: Apoidea) and syrphid flies (Diptera: Syrphidae) which could utilize soybean flowers. One or two fields per state were sampled, and fields were bordered by a variety of other land uses, ranging from restored prairie to corn and soybean fields. Bees and syrphid flies were collected using yellow "bee bowls" placed on stakes just above the plant canopy at intervals along a single transect in each field to determine what species were present and how far from field edges they could travel. All sampled fields were planted with non-insecticide treated seed. Samples were collected twice weekly during flowering, and bees and syrphid flies were identified to species. To date, 43 bee species in 17 genera, representing five families, and 12 syrphid fly species in six genera have been identified. The most abundant bee genera collected were *Lasioglossum* (17 spp.) constituting 71.1% of bee specimens, *Agapostemon* (3 spp.) 10.5%, *Melissodes* (7 spp.) 10.4%, and *Halictus* (3 spp.) 3.3%. Syrphid flies were dominated by *Toxomerus* (2 spp.), which made up 94.3% of all syrphid specimens. To date, approximately 75% of the samples have been processed.

P008 Pesticide contaminants found in bee hives placed in agricultural and non-agricultural habitats

*Scott D. Stewart[1], sdstewart@utk.edu, Heather Kelly[1], John Skinner[1], Mohamed Alburaki[1], Gus Lorenz[2], Don Johnson[2], Jon Zawislak[2], John Adamczyk[3], William Meikle[4], and Milagra Weiss[4]

[1]The University of Tennessee, Department of Entomology and Plant Pathology, Knoxville, TN; [2]University of Arkansas, Department of Entomology, Fayetteville, AR; [3]USDA ARS, Southern horticultural Laboratory, Poplarville, MS; [4]USDA ARS, Carl Hayden Bee Research Center, Tucson, AZ

Pesticides, and neonicotinoid insecticides in particular, are being targeted by activist groups as a primary cause of declining pollinator health, and this has caused increased scrutiny by regulatory agencies on the use of pesticides in row crop agriculture. In 2014, hives were placed in intense agricultural areas and low agricultural areas of Arkansas and Tennessee. Samples of bees, pollen stores, honey and wax were collected in the fall to determine what pesticide contaminants were present in the hives. Partial and preliminary results from 2014 indicate no neonicotinoids were detected in the pollen stores, honey, adult bees, bee brood, or wax from hives placed in agricultural areas, despite some hives being fed sublethal doses of imidacloprid in sugar water. Despite no treatments being made for varroa mites, the wax collected from these hives was contaminated with fluvalinate (mean = 77 PPB) and coumaphos (mean = 144 PPB), pesticides commonly used for control of this pest. Presumably, these miticides were present in the foundation wax when hives were established. Lambda-cyhalothrin (mean = 4.3 PPB) was detected in pollen stores from hives placed in an intense agricultural area of Arkansas. Two fungicides were detected in these same pollen stores (azoxystobin, mean = 55 PPB; tebuconazole, mean = 3.3 PPB). Reports of pesticide contaminates found in hives located in Tennessee have not been received by the time of this report. However, additional data are expected to be available by the time of this poster presentations.

P009 A new fungicide, insecticide, nematicide combination for nematode management in cotton

*Kathy S. Lawrence[1], lawrekk@auburn.edu, and Gary W. Lawrence[2]

[1]Entomology & Plant Pathology, Auburn University, Auburn, AL; [2]Biochemistry, Molecular Biology, Entomology, & Plant Pathology, Mississippi State University, Mississippi State, MS

Cotton (*Gossypium hirsutum* L.) is economically damaged primarily by two nematode species, the reniform nematode (*Rotylenchulus reniformis* Lindord & Oliveira) and root-knot nematode (*Meloidogyne incognita* race 3 (Kofoid & White)

Chit. Cotton cultivars elicit yield losses due to these nematodes thus combinations of cultivar and pesticides may reduce damage. Replicated field trials, tolerant and susceptible cotton cultivars were tested in combination with either: 1) an insecticide; 2) a granular nematicide; 3) a seed treatment nematicide; 4) insecticide + fungicide + seed treatment nematicide; 5) insecticide + fungicide; or 6) seed treatment nematicide + foliar insecticide/nematicides. Plant stand or survival near 4 weeks after planting was similar for both cotton cultivars and all pesticide combinations with an average of 10 plants per m of row. Reniform and root-knot population densities were very high in both years at the 4-6 weeks sampling period. The susceptible cultivar supported greater numbers of nematodes per gram of root or 500 cm^3 of soil than the tolerant cultivar. The insecticide + fungicide + seed treatment nematicide reduced nematode egg density ($P < 0.10$) similarly to the standard granular nematicide. This reduction in fecundity was consistent over years and nematode species. Seed cotton yields were greater ($P < 0.10$) in the tolerant cultivar compared to the susceptible. Yields were improved similarly in the insecticide + fungicide + seed treatment nematicide combination as compared to the granular nematicide alone. The insecticide + fungicide + plus seed treatment nematicide combination also enhanced yields over all other pesticide combinations.

P010 Potential of incorporating sugarcane host resistance in integrated nematode management

*Alexander Chirchir[1,2],alkchirchir@yahoo.com, John Kimenju[2], Emmanuel Ariga[2], George Kariuki[3] and Chrispine Omondi[4]

[1]Department of Crop Development, KALRO- Sugar Research Institute, Kisumu, Kenya; [2]Department of Plant Science and Crop Protection, Faculty of Agriculture, University of Nairobi, Nairobi, Kenya; [3]Department of Agricultural Science and Technology, Kenyatta University, Nairobi, Kenya; [4]Department of Plant Breeding, KALRO-Coffee Research Institute, Ruiru, Kenya

A field study was conducted to assess the potential of incorporating host resistance in an IPM strategy for nematode management in sugarcane production. Three sugarcane cultivars namely KEN 83-737, N14 and Co 421 rated respectively as resistant, tolerant and susceptible to plant parasitic nematodes were selected and planted under three different rates (recommended, half the recommended and nil) of the nematicide aldicarb (Temik 10G). The different cultivars had significant ($p \leq 0.05$; $p \leq 0.01$) differences measured in their plant height and millable stalk number. Similarly, application of the nematicide significantly increased the girth, plant height, millable stalks number and yield of sugarcane. Further, interaction between the different cultivars and nematicide rates improved all the yield components which were highest in the recommended and lowest in the nil (control) rates. The recommended nematicide rate significantly improved the quality of sugar. This study has established that host resistance may be incorporated in an integrated strategy together with other practices to reduce nematode numbers in the soil with the consequent improvement of the yield and quality of sugarcane.

P011 Laboratory assay of entomopathogenic nematodes against wheat stem sawfly, *Cephus cinctus*

*Sindhu Krishnankutty, sindhu.krishnankutty@montana.edu, Brian Thompson, Debra A. Miller, and Gadi V.P. Reddy

Western Triangle Agricultural Research Center, Montana State University, Conrad, MT

Infectivity of different entomopathogenic nematodes (EPNs) have been proven against hundreds of species of insects in laboratory and field tests. No prior information is available on the dose-response relationship of different species of EPN against wheat stem sawfly (WSS). This study aims to compare the susceptibility of EPNs against WSS. Five different species, *Heterorhabditis indica*, *H. bacteriophora*, *Steinernema kraussei*, *S. carpocapsae*, and *S. feltiae* were evaluated in a laboratory bioassay. EPNs were applied at the rates of 50, 100, 200 and 500 IJs/petri dish in 0.25 ml of water. Treatments were evaluated for one week after EPN application. Significant difference was found among the treatments. Among the five different EPN species, *H. indica* caused highest mortality (100%) within 48 hrs after the application.

P012 Pulse crop disease management: The role of a new regional pulse crop diagnostic laboratory in Montana

*Bright O. Agindotan, bright.agindotan@montana.edu, and Mary E. Burrows

Department of Plant Sciences and Plant Pathology, Montana State University, Bozeman, MT

Pulse crops, including chickpeas (*Cicer arientum*), field peas (*Pisum sativum*), and lentils (*Lens culinaris*) are increasing in acreage due to their use in rotation with cereals and their value as cash crops. Most US-grown pulses are exported to international markets, and Montana and North Dakota are the leading producers. A major constraint to pulse production is diseases that reduce yield and lower seed quality. Economically important diseases of pulses include Aschochyta blight caused by *Aschocyta* and *Mycosphaerella* spp., and anthracnose caused by *Colletrotrichum* spp. Virus, bacterial and nematode pathogens including Pea seedborne mosaic virus, Pea early browning virus, Bean leafroll virus, *Psuedomonas syringae* pv. *pisi* (bacterial blight), and *Ditylenchus dispaci* (stem worm). Many of these pathogens are seedborne and regulated by phytosanitary restrictions by the importing country. In addition, fungicide resistance to QoI and SDHI fungicides has been identified in *Ascochyta rabiei*, and QoI resistance in *Mycosphaerella pinodes*. Diseases persist partly because of limited access to testing

services, the use of susceptible varieties, and tight crop rotations. Control and management of these diseases by determining the health status of seed lots for planting will be facilitated by access to testing services. A new Regional Pulse Crop Diagnostic Laboratory has been established at Montana State University, Bozeman, to provide comprehensive, affordable and reliable diagnostic services for pulse crop pathogens. Fungicide resistance, variety resistance screening, and discovery of new pathogens are research components of the laboratory. Close relationships with growers, industry, and government stakeholders will facilitate education and international trade.

P013 not presented

P014 Influence of cultivar, fungicide, and weather on frogeye leaf spot disease and yield in soybean

*Heather M. Kelly, youngkelly@utk.edu, and Melvin A. Newman

University of Tennessee, Department of Entomology and Plant Pathology, Knoxville, TN

Frogeye leaf spot (FLS) caused by *Cercospora sojina* Hara, is a common foliar pathogen of soybean in the southern United States and regularly present in parts of the Midwestern United States. Infection due to this disease can cause dramatic loses of photosynthetic area and premature senescence leading to yield losses ranging from 20-40% in years where weather conditions are favorable for disease development. Producers, in areas where FLS has historically caused yield losses, have attempted to combat the disease with cultivar selection and a foliar fungicide spray regime. Yearly cultivar trials were conducted in Milan, TN from 2003–2013 in continuous no-till. Cultivars were arranged in a randomized split-plot design, with cultivars as the main plot and fungicide application at growth stage R3 as sub plots with 3 to 4 replications. Cultivars tested included maturity group (MG) III, MG IV, and MG V. The severity of FLS and yield on treated and non-treated plots were recorded to determine FLS effect on cultivar and the effect of fungicide application on FLS severity and yield of each cultivar. Effect of weather on FLS development and cultivar yield was also analyzed. Results based on this research continue to support that some of the most useful techniques for producers to manage FLS and increase yield are cultivar selection coupled with an appropriate fungicide regime. Further classification of cultivars into low, moderate, and highly susceptible categories and inclusion of weather variables may better guide fungicide decisions.

P015 Effects of thiamine treatment to control PVY on potatoes

Amber C. Vinchesi, Aymeric Goyer, and *Silvia I. Rondon, silvia.rondon@oregonstate.edu

Department of Crop and Soil Sciences, Oregon State University, Hermiston Agriculture Research and Extension Center, Hermiston, OR

Potato Virus Y (PVY), a non-persistent virus transmitted by aphids, is an important disease of potatoes worldwide that causes significant yield loss, especially in the Pacific Northwest. Foliar symptoms include mosaic, chlorosis, leaf drop and certain PVY strains cause Potato Tuber Necrotic Ringspot Disease (PTNRD) in tubers. Thiamine (vitamin B1) has been shown in many crops to boost the plant's immunity and increase its resistance against pathogens by inhibiting disease progression. Our objective was to test the effects of thiamine on potato resistance to PVY. We conducted a screenhouse study to determine whether thiamine provided resistance against PVY. We tested different densities of aphids (1, 5, 10/plant) on potatoes using four treatments of thiamine at different concentrations (0, 1, 10, 50 mM) in a randomized complete block design. We released aphids negative for PVY into clip cages on our "clean" plants in each plot, and mechanically inoculated "hot" plants in each plot with PVYN:O. We collected weekly leaf samples and made visual observations of foliar symptoms. ELISA will be used to determine PVY presence in leaflets and whether thiamine delays disease expression. Tubers were individually hand-harvested, weighed, and checked for PTNRD symptoms, though none were found. Treatment 4 (50 mM thiamine) was the only treatment with a similar yield to the control. All other treatments (T1, T2, T3) had significantly lower mean yields compared to the control. These are preliminary results for the first attempt of thiamine as a control measure on potatoes.

P016 Applied management options to enhance crop safety against verticillium wilt

*Caroline Land[1], CJL0006@Auburn.edu, Kathy Lawrence[1], Charlie Burmester[2], and Brad Meyer[3]

[1]Entomology and Plant Pathology, Auburn University Auburn, AL; [2]Crops, Soils, and Environmental Sciences, Auburn University Auburn, AL; [3]AGRI-AFC, Decatur, AL

Verticillium wilt of cotton (*Gossypium hirsutum* L.) is caused by *Verticillium dahliae*, which colonizes the vascular cylinder of the plant resulting in defoliation, stunting, and yield loss. In Alabama, *V. dahliae* and *V. albo-atrum*, were found in the northern regions. In the southern half of the state, Verticillium wilt is uncommon and only *V. albo-atrum* was isolated. Cotton varieties were evaluated for resistance to verticillium wilt in 2013-2014. In 2013, the least amount of foliar disease and vascular necrosis was found in ST4747GLB2, FM1944GLB2, PHY339WRF, and DP1044B2RF. The following season, ST4946GLB2 and FM1944GLB2 performed well with high yields and lower disease. Disease incidence and severity correlated with yield ($P < 0.001$) indicating disease reduced yield by 48%. Microplot trials were performed to determine

if irrigation and soil type affected diseases expression. The microplot test was arranged in a split plot factorial design with six soil types as the main factor and irrigation or dry land condition (natural rainfall) was the secondary factor. Irrigation significantly increased disease incidence and severity compared to the non-irrigated soils. Irrigation increased disease across all soil types approximately 121% compared to non-irrigated plots. Decatur Silt Loam and the Houston Clay soil types had significantly more disease.

P017 Maine potato IPM program: Past-present-future

*James Dwyer, jimdwyer@maine.edu, James Dill, Steven Johnson, Griffin Dill, and Sean McAuley

University of Maine Cooperative Extension, Orono, ME

The University of Maine Cooperative Extension Potato IPM Program has been a fluid program, continually adapting to help Maine's potato producers cope with a multitude of changing pest issues. The program was initiated in the 1970's as Aphid Alert, an aphid-focused platform designed to address issues with potato leaf roll and potato virus Y(PVY). The program was then expanded to include the management of Colorado potato beetles and incorporated the use of an economic threshold approach to insect control. Disease forecasting and fungicide scheduling were later added to assist growers in the management of late blight. As European corn borer became an increasing threat for potato producers in Maine, the program expanded into black light and pheromone trapping as well as modified degree-day modeling. In recent years, the significant threat posed by PVY and the recombinant strains of PVY has required an increased focus on the management of both colonizing and non-colonizing aphids. Today the Potato IPM Program provides growers with a comprehensive strategy to manage a host of insect and disease pests including aphids, Colorado potato beetles, flea beetles, European corn borer, wireworms, potato late blight, early blight and white mold. The program continues to adapt to address the changing needs of Maine's dynamic potato industry, therefore the program is moving toward more reliance on predictive modeling and new technologies.

P018 Management of fusarium wilt in upland cotton of the southeastern United States

*Amber L. Smith[1], als0019@auburn.edu, Kathy S. Lawrence[1], Kathryn Glass[2], and Edzard van Santen[2]

[1]Department of Entomology and Plant Pathology, Auburn University, Auburn, AL; [2]Department of Crop, Soils, and Environmental Sciences, Auburn University, Auburn, AL

Fusarium oxysporum f. sp. *vasinfectum* (W. C. Snyder & H. N. Hansen) causes economic losses of Upland cotton (*Gossypium hirsutum*) yields throughout the cotton belt of the United States. An association with the Southern root-knot nematode (*Meloidogyne incognita*) was recognized early on in the discovery of the disease, forming a disease complex. The symptoms of Fusarium wilt include stunted plants, wilting, chlorotic and necrotic leaves, leaf abscission, discolored vascular tissue inside the stem, yield loss, and death. A trial to screen commercially available cultivars for resistance or tolerance to the Fusarium wilt disease complex was installed at a research farm in central Alabama. Plant survival rates were calculated and biweekly disease evaluations were taken throughout the season until plant maturity to determine percentages of varieties that were infected. Stoneville (ST) 4747, ST 4946, ST 6448, Phytogen (PHY) 339, PHY 427, and Deltapine 1321 all had low Fusarium wilt incidences. Diseased plants were removed from each plot and the wilt pathogen was isolated onto media for pathogen confirmation. Once visually confirmed, isolates of the pathogen were molecularly identified via DNA extraction and PCR amplification to determine races present in Alabama. Race 1 was the predominant race found in Alabama, with 70% of isolates identifying as this race. 14% of isolates were LA 108, 8% were race 8, 7% were LA 127/140, and 0.008% were identified as race LA 110. A greater variety of races was found to be present earlier in the season.

P019 Chemical treatments and host resistance reduced white mold and enhanced yield of soybean in Ohio

*Jaqueline Huzar Novakowiski, huzarnovakowiski.1@osu.edu, Clifton Martin, and Anne E. Dorrance

Department of Plant Pathology, The Ohio State University, Ohio Agricultural and Development Center–OARDC, Wooster, OH

Recent outbreaks of white mold or Sclerotinia stem rot of soybean caused by *Sclerotinia sclerotiorum* in Ohio has led to a resumption of evaluations of different disease management strategies. The objective of the study was to compare the effectiveness of fungicides and herbicides labeled for "disease suppression" applied to soybean cultivars with different levels of resistance to *S. sclerotiorum*. The study was carried out in Gustavus Center, OH in 2014 with ten different chemical treatments, including four fungicides and an herbicide with two different application timings (R1 and R2) and four soybean cultivars arranged in a strip plot randomized block design with 8 replications. Disease incidence ranged from 3% to 52%, whereas disease severity index ranged from 2 to 41 depending on the soybean cultivar and chemical treatment. None of the chemical treatments provided complete control of the disease; however, Phoenix and Endura at both application timings had significantly lower disease levels than the nontreated control. More importantly, the soybean cultivar with the highest rating for resistance to *S. sclerotiorum* had significant lowest levels of the disease. Yield was significantly different among the chemical treatments depending on the soybean cultivar. Management of white mold is very challenging, partially due to the variability

of incidence and severity of the disease observed among years. Consequently, our initial findings indicate that growers should focus on selecting cultivars with the best resistance ratings to manage this disease effectively.

P020 Survey of fungal diseases in commercial soybean fields in South Dakota

Febina Mathew, Paul Okello, Ahmed Gebreil, and *Darrell Deneke, Darrell.deneke@sdstate.edu

Department of Plant Sciences, South Dakota State University, Brookings, SD

In 2014, a disease survey was conducted in commercial soybean (*Glycine max* L.) fields in South Dakota. Evaluations were made on foliar and root diseases infecting soybean plants. Two hundred fields covering 22 counties were surveyed in late August or early September. The fields were arbitrarily selected and had a cropping history of corn (*Zea mays* L.), sunflowers (*Helianthus annuus* L.) and wheat (*Triticum sp.*) rotated with soybeans. A one acre section of each field was used for disease evaluations and about 2000 soybean samples (10 plants per field) were collected between R1 (beginning flowering) and R5 (beginning seed) growth stages. Among the soybean fungal diseases, Sudden death syndrome was found in 20% of the fields surveyed and was the most prevalent of the fungal diseases observed. Phytophthora stem rot was the second most common foliar disease and observed in 12% of the fields. One of the driving factors for development of Sudden death syndrome and Phytophthora stem rot this season was significant rainfall during the late-vegetative and early reproductive growing period. Other diseases in low prevalence (< 10%) were Stem canker, Downy mildew, White mold, Septoria brown spot and Charcoal rot. Among the fungal root pathogens, Fusarium species were most recovered from soybean roots (88%). Other isolated fungi from the roots in low numbers (<10%) were *Diaporthe sp.*, *Macrophomina phaseolina*, *Pythium sp.*, and *Rhizoctonia solani*.

P021 Prevalence and virulence of downy mildew on sunflowers in North Dakota

*Michelle Gilley[1], michelle.gilley@ndsu.edu, Thomas Gulya[2], Christopher Misar[2], and Samuel Markell[1]

[1]Department of Plant Pathology, North Dakota State University, Fargo, ND; [2]USDA-ARS Northern Crop Science Laboratory, Sunflower and Plant Biology Research Unit, Fargo, ND

Downy mildew [*Helianthus annuus* L.] is a yield-limiting sunflower disease caused by *Plasmopara halstedii* [(Farl.) Berl. and de Toni]. Genetic resistance is one of the most important management tools for the disease. However, multiple resistance genes have been overcome by the evolution of pathogen races, and the incorporation of additional resistance genes into commercial hybrids is needed. Assessment of pathogen virulence is critical for determining what resistance genes should be incorporated into hybrids. The objectives of this study are to determine the prevalence of downy mildew in North Dakota and determine the virulence of *P. halstedii* isolates collected from the region. In 2014, 105 fields were surveyed by visually assessing 40 plants at five locations for signs and symptoms of downy mildew. Sixty-five percent of those fields had downy mildew and ten fields had field-wide incidence levels higher than 5%. To determine the virulence phenotypes of *P. halstedii* in the region, 220 pathogen samples were collected from surveyed fields and from cooperator submissions. Selected isolates were evaluated on the standard nine *P. halstedii* differentials and up to ten supplemental lines with different genetics. Virulence to the majority of the differential lines was found, but virulence was not observed on many supplemental lines. The identification of lines with resistance effective to *P. halstedii* is an important first step for breeding resistance to this economically important disease.

P022 Evaluation of a novel fungicide compound for management of downy mildew on sunflower

*Ryan Humann[1], ryan.m.humann@ndsu.edu, Keith Johnson[2], Tom Gulya[3], Scott Meyer[1], Jim Jordahl[1], Elizabeth Crane[1], Andrew Friskop[1], Michael Wunsch[4], and Sam Markell[1]

[1]Department of Plant Pathology, North Dakota State University, Fargo, ND; [2]DuPont Field Development, Grand Forks, ND; [3]USDA-ARS Northern Crop Science Laboratory, Sunflower and Plant Biology Research Unit, Fargo, ND; [4]Carrington Research Extension Center, North Dakota State University, Carrington, ND

Downy mildew of sunflower [*Helianthus annuus* L.] is a yield-limiting disease caused by the Oomycete pathogen, *Plasmopara halstedii* [(Farl.) Berl. and de Toni]. Fungicidal seed treatments are an important management tool, but currently only one seed care package is labeled for suppression of downy mildew on sunflowers. The objective of this study was to evaluate the field efficacy of oxathiapiprolin applied as a seed treatment for the management of downy mildew. Oxathiapiprolin belongs to a new mode of action that targets an oxysterol-binding protein domain specific to some Oomycetes. Thirteen field trial locations were conducted from 2011 to 2014, artificially inoculated with *P. halstedii* zoosporangia and irrigated after inoculation. Incidence levels were determined by recording systemically infected plants three times throughout the growing season. In the trials with measurable disease pressure, all treatments that contained oxathiapiprolin had significantly lower disease incidence levels than the non-treated checks and had the same or lower incidence levels than the fungicide standards. Results indicate that oxathiapiprolin could provide another fungicidal seed treatment option for downy mildew.

P023 RT-qPCR: A reliable assay for routine detection of RNA viruses of cereals and grasses

E. Svobodová, T. Dráb, J. Ripl, J. Jarošová, and *J. K. Kundu, jiban@vurv.cz

Division of Crop Protection and Plant Health, Crop Research Institute, Prague, Czech Republic

Detection of the Poaceae viruses has focused mainly on cereal crops and has been usually limited only to the most widespread viruses. ELISA was the method of choice for routine diagnosis of these viruses, but over the last few years techniques based on (RT)-qPCR have become more and more important and widespread for routine plant virus detection and quantitative analysis of the virus titers. Less prevalent viruses of family Poaceae are usually excluded from the main focus of interest, even though they may represent a possible threat to agricultural production. We designed and validated a set of primer pairs suitable for detection and quantification of RNA viruses—BYDV (barley yellow dwarf virus), LoLV (Lolium latent virus), ONMV (oat necrosis mottle virus), RgMV (ryegrass mosaic virus), SBCMV (soil-borne cereal mosaic virus), and SpMV (Spartina mottle virus) by means of one step RT-qPCR based on SYBR Green I. These primers were used together with primers for BMV (brome mosaic virus) and WSMV (wheat streak mosaic virus) described elsewhere for screening of grass and cereal samples from the Czech Republic. Its results revealed a high prevalence of WSMV and RgMV, which pointed to possible local epidemics. We also bring the first report of LoLV presence in the Czech Republic.

P024 The Sunflower Pathology Working Group

*Sam Markell[1], samuel.markell@ndsu.edu, Bob Harveson[2], Charlie Block[3], Tom Gulya[4], and Febina Mathew[5]

[1]Department of Plant Pathology, North Dakota State University, Fargo, ND; [2]University of Nebraska, Scottsbluff, NE; [3]Plant Introduction Station-USDA-ARS, Ames, IA; [4]USDA-ARS Northern Crop Science Laboratory, Sunflower and Plant Biology Research Unit, Fargo, ND–Retired; [5]Department of Plant Science, South Dakota State University, Brookings, SD

Approximately 85-90% of the 2.0 M acres of sunflower planted annually in the US are in the North Central States. Although diseases have been consistently one of the most significant biotic yield-limiting factors for sunflower production in this region, very few pathologists work on sunflower. Consequently, limited scientific reference material and Extension literature on sunflower diseases exists. This void has resulted in frequent misidentification of diseases and a lack of IPM recommendations; growers often 'spray and pray'. In 2013, funding was obtained from the North Central IPM Center to establish the Sunflower Pathology Working Group (SPWG). The SPWG has four objectives; 1) Identify the greatest sunflower pathology and IPM informational needs among growers, 2) Develop literature to address grower needs, 3) Address a lack of scientific reference material by composing the first American Phytopathological Society—Sunflower Compendium, and 4) Increase communication among pathologists working on sunflower. In 2013, a survey designed to identify the greatest informational needs and preferred method of delivery was distributed to stakeholders in several different ways. In response, a sunflower field diagnostic guide highlighting 20 different diseases was developed. Additionally, the first Sunflower Compendium is being drafted and will likely be available in 2016 and technical sunflower pathology chapters have been incorporated into two books. As a result of the publications spearheaded by the SPWG, communication among pathologists working on sunflower has increased dramatically, particularly internationally.

P025 An integrated approach to managing slugs in no-till corn systems

*Joanne Whalen[1], jwhalen@udel.edu, William Cissel[2], Philip Sylvester[2], and Richard Taylor[3]

[1]Department of Entomology, University of Delaware, Newark, DE; [2]University of Delaware Cooperative Extension; [3]Plant and Soil Sciences Department, University of Delaware, Newark, DE

Slugs continue to present a major challenge in conservation tillage cropping systems. The environmental benefits of conservation tillage, including a reduction of soil erosion and nutrient loss and improvements in soil health, have led to a widespread adoption of this farming practice in the Mid-Atlantic region. However, the adoption of no-tillage production of field corn has resulted in an increase in economic losses from slug damage to field corn systems. Funded by the E-IPM Program, our team has focused on the use of the use of pre-season monitoring and treatment thresholds on twenty farms per year from 2011 through 2013 to identify areas with potential slug problems. To address the need for alternative management programs that also maintain soil health, we demonstrated the effectiveness of a combination of cultural practices for slug management including vertical tillage, row cleaners, disking and reduced risk mollusicides on four farms per year from 2011 through 2014. In the winter of 2014, 200 growers gained knowledge about sampling methods, treatment guidelines, and the use of cultural management and reduced risk mollusicides at 3 county meetings and one state-wide Agronomy Meeting. An additional 300 producers were educated through our state statewide newsletter, Weekly Crop Update about slug management in field crops. New information on slug management in field corn in the Mid-Atlantic was posted to the University of Delaware IPM Webpage (http://extension.udel.edu/ag/category/hot-topics/insects/) and incorporated in the Regional Agronomy Newsletter (http://

www.psla.umd.edu/extension/extension-project-pages/mid-atlantic-regional-agronomist-newsletter).

P026 Mitigation of corn rootworm with Bt traits and SAI–An industry perspective for BMP development

*Sean Evans, spevan@monsanto.com, Luke Samuel, LeAnna Wegh, Doug Jones, Tom Kladar, Preston Schrader, and John Cantwell

Monsanto Company, St. Louis, MO

Collectively, corn rootworms (*Diabrotica* spp.) are amongst the most economically-significant pests of corn in many regions of the US. Crop rotation remains as the leading best management practice (BMP) in instances where corn rootworm populations are expected to be high. However, mitigation of larval feeding may also involve within crop use of rootworm control products including hybrids expressing Bt. proteins and/or soil-applied insecticides. In 2012–2014, Monsanto personnel implemented field protocols as a means to evaluate the efficacy of Monsanto Bt. traits used alone and in combination with soil-applied insecticides. Trials were initiated across the corn growing area of the US on fields where the potential for rootworm larval damage was anticipated to be high based on observation and management history. The root damage ratings and crop yield from those studies will be summarized and discussed with emphasis on the relevancy of these data on development and validation of Monsanto's BMPs for management of corn rootworm as part of a farm-wide IPM program.

P027 Insect resistance management by systemic insecticide border treatment and egg parasitoids

Shunichi Shibuya, hymenoptera072@outlook.jp

Shibata, Miyagi, Prefecture, Japan

When systemic insecticides are applied more than six times, restoration is born of detoxification to the inhibition of DNA and protein synthesis in fat bodies. This oogenesis with sub-lethal toxicity ceases in the following embryogenesis to early embryonic stage before blastoderm formation when host eggs are suitable to parasitoids. Therefore, all host eggs are targets of egg parasitoids, following high parasitism. With normal embryogenesis, parasitism corresponds to the embryonic developmental stage before "dorsal closure", and is lower than a third term in eggs of Chrysomelidae. In June 2014, high parasitism (98 *Anaphes nipponicus* adults per 100 *Oulema oryzae* eggs) was observed in paddy fields treated with Fipronil eight times from 2002 to 2012. Eggs were laid, but we couldn't determine the hatch. If it was due to insecticide pressure, the embryogenesis of resistant populations will be restored and the huge population of egg parasitoids will be lost. To keep the mixture of sensitive and resistant populations to maintain sub-lethal toxicity, we must save a low density of host pests sensitive to insecticide. *O. oryzae* had higher density in the borders, their entry point into rice fields. As a result of this partial control, high parasitism by *A. nipponicus* for *O. oryzae* eggs with sub-lethal toxicity continued through biological control without insecticides in the middle part and with insecticides in paddy borders. Results show that border treatment with systemic insecticide while using egg parasitoids achieves Insect Resistance Management. Abnormal oogenesis with sub-lethal toxicity is described with spiromesifen, novaluron, chlorantraniliprole, chlorfluazuron and other insecticides.

P028 Promising myco-herbicide from *Cochliobolus lunatus* (SBT 030) for weed (*E. crus-galli*) management in rice

*KRK Reddy[1], sribio@gmail.com, AR Podile[2], G Jyothi[1], and KRN Reddy[1]

[1]R&D Center, Sri Biotech Laboratories India Ltd., Hyderabad, Telangana, India; [2]Department of Plant Sciences, University of Hyderabad, Hyderabad, Telangana, India

Rice is one of the important food crops of the world and is the second emerging crop in India after wheat. The average per hectare yield in India is less as compared to China due to various factors. Among them weed emergence is the major contributor in the loss of rice production. Due to weeds, heavy rice yield losses have occurred, sometimes to the extent of complete crop loss under extreme conditions. Keeping this in mind, experiments were designed to develop environmentally safe products for controlling notorious weeds in rice crops. Field surveys were conducted in ten districts of Andhra Pradesh and found *Echinochloa crus-galli* as the dominant weed occurring in paddy fields. The naturally infected weed samples were collected and 56 fungal pathogens were isolated. Among them three fungal pathogens *Fusarium proliferatum*, *Alternaria alternata* and *Cochliobolus lunatus* are identified as virulent pathogens against *E. crus-galli*. Extracted crude metabolites from all 3 pathogens were tested on *E. crus-galli* under greenhouse and field conditions. The metabolites extracted from *C. lunatus* are found very effective in controlling the weed even at lower concentrations after 7 days of treatment. Cheaper nutrient media was optimized for large scale production of potential metabolites. The effective metabolite was purified with preparative HPLC and characterized through LC- MS, IR and NMR spectroscopy. The potential metabolite was identified as Oleic acid with molecular weight 283 and molecular formula C18H34O2. We developed both organism and metabolite formulations and are generating the required data for statutory approvals.

P029 Present status of weed and weed management in rice in Sri Lanka

Anuruddhika S.K Abeysekera, rrdiweedscience@gmail.com

Rice Research and Development Institute, Department of Agriculture, Batalagoda, Sri Lanka

Rice farming is a major cropping strategy in uplifting the livelihood of 1.5 million farm families in Sri Lanka. Intensification of rice culture with the use of high yielding, short duration, semi-dwarf varieties, and increasing the use of fertilizer and agrochemicals were some of the major factors that influenced the socioeconomic environment and the agricultural ecosystem in the country. At present more than 142 weed species are identified in rice fields. Among these more than 78 species are grasses and 52 species are sedges. About 10-20 weed species belong to the broadleaf category. The use of chemicals has become the predominantly adopted cost effective option among more than 90% of farmers. Yield losses caused by weeds in rice fields have been estimated by different researchers in different locations in the country to range from 30%-50%. This is due to poor implementation of cultural practices and incorrect application of chemicals. Chemical weed control has made remarkable progress over the past 4-5 decades. In the early 1960's phenoxy herbicides, in the late 1980's formulation mixes of propanil herbicides and after the 1990's sulfonylurea herbicides were popular among farmers. Currently, however, after repeated use of some herbicides in every cropping season many rice fields have herbicide resistant weeds: *Echinochloa crusgalli*, *Cyperus iria*, *Cyperus difformis*, etc. The Department of Agriculture has been promoting several strategies to minimize the weed problem, including a rotation management program with changes of herbicide and other non-chemical control methods.

P030 Present status of herbicide usage in Sri Lankan paddy cultivation

*Anuruddhika S.K Abeysekera, rrdiweedscience@gmail.com, Darusha D. Witharana, and Sakinda D. Kulatunga

Rice Research and Development Institute, Batalagoda, Sri Lanka

Rice is the staple food and it is the livelihood of the majority of farmers in Sri Lanka. Recently rice cultivation has been shifted from transplanting to direct seeding where weed growth becomes more rapid and extensive. Popular rice varieties which have 90-105 days duration, required intensive weed management. It is important to control weeds from their initial interference. Farmers were shifted to chemical weed control due to scarcity of labour and labour cost. Before the 1990's, herbicides were not significantly used in rice cultivation. Currently herbicides became dominant in the market where they contribute to 60% of total agrochemical imports. Importations of herbicides were 1881.89 Mt in 2000, 3883.1 Mt in 2005, and 6972.21 Mt in 2010. In year 2012 total herbicide import volume was recorded as 5130.81 Mt and 51% of that volume was used in paddy cultivation. Pre-emergence and post-emergence herbicides which have 11 modes of actions with 39 different molecules, traded under more than 200 brand names. Increased incorrect use of herbicides shifted weed flora from annuals to perennials such as *Isachne globosa*, *Paspalum* spp., *Murdania nudiflora*, etc. The majority of framers tended to follow their own recipes and poor cultural management practices. Because of that, several isolated locations around the country have reported resistance against the few selected herbicides. Hence, it is important to study the present usage and the applications of herbicides in the paddy cultivation to develop sustainable weed control measures.

P031 New and refined IPM tactics and tools for rice water weevil management in California rice

*Larry D. Godfrey[1], ldgodfrey@ucdavis.edu, Mohammad-Amir Aghaee[1], Kevin Goding[1], and Luis Espino[2]

[1]Department of Entomology and Nematology, University of California, Davis, CA; [2]University of California Cooperative Extension, Colusa, CA

The rice water weevil (*Lissorhoptrus oryzophilus* Kuschel) is the most important insect pest of California rice (*Oryza sativa* L.). Larval feeding reduces grain yields through root pruning during the vegetative stage; this injury reduces development of new tillers and the resulting panicles and grain. Larvae are adapted to the anoxic environment of flooded rice fields by having modified chitinized spiracles, shaped as dorsal hooks, which pierce root tissue enabling them to obtain oxygen from the plant. Grain yield losses up to 35% from rice water weevil feeding have been recorded in California. Management of this pest has relied on insecticides supplemented by cultural control methods. Insecticides used have progressed from organophosphate, carbamate, and pyrethroid products during the 1990's and early 2000's to neonicotinoid and anthranilic diamides in 2015. The proximity of rice agroecosystems to the Sacramento River and other important waterways makes the use of insecticides challenging. Recent research has investigated the efficacy of a biological insecticide, *Bacillus thuringiensis* subspecies *galleriae*, against rice water weevil. Greenhouse studies showed efficacy equal to that from a commonly-used pyrethrid insecticide. Secondly, winter flooding was investigated as a management tool for this pest the following spring. Winter flooding is a common practice used to mitigate straw residue and to provide habitat for wintering waterfowl. Finally, although there is not well-developed host plant resistance for rice water weevil, some of the newly developed cultivars appear to respond less negatively to larval feeding than older ones. This response was qualified and used to modify management recommendations.

P032 Zone management and cotton IPM: Site specific control of *Lygus lineolaris* in irrigation management zones

*Tina Gray Teague[1], tteague@astate.edu, Keith Morris[2], and David Wildy[3]

[1]University of Arkansas Agricultural Experiment Station, Arkansas State Universiy, Jonesboro, AR; [2]Agricultural Systems Technology, Arkansas State University, Jonesboro, AR; [3]Wildy Family Farms, Manila, AR

Crop production decisions have grown more complex as advanced spatial technologies have become available. Producer decisions on cultivar selection, Zone management for agronomic inputs has become standard on many Midsouth cotton [*Gossypium hirsutum*] farms. Use of site specific approaches for insect control is lacking. This poster summarizes a simple zone approach for late season to control tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), a key pest of Midsouth cotton. Zone management for insecticide control termination was evaluated in irrigated and rainfed management zones in a center pivot irrigated field during the three growing seasons in Northeast Arkansas. A replicated strip trial across center pivot irrigated "circles" and rainfed "corners" was used to validate the use of NAWF-based measures of crop maturity to time the final late-season insecticide applications. In the three year study, no reduction in yield was associated with following crop termination rules using the crop monitoring to determine date of physiological cutout and terminating control after last effective bolls had accumulated 250 DD60s. These data support adoption of a zone management approach in late season crop protection practices. Producers that have auto-guidance technology can employ map-based selective applications to apply protectants only to areas of the field still vulnerable to late season infestations. Adoption of this approach will allow producers to offset rising protection costs (there was a 13 % reduction in cost for 1 to 2 applications) as well as reduce environmental impact of applications at the edge-of field demonstrated using the Field Print Calculator.

P033 not presented

P034 Developing strategies to manage thrips in peanut in absence of aldicarb

*R. Brandenburg, rick_brandenburg@ncsu.edu, D. Jordan, B. Royals, and D. Johnson

North Carolina State University, Raleigh, NC

Tobacco thrips can have a major impact on peanut yield if control measures are not implemented especially in North Carolina where the growing season for peanut is relatively short and injury can delay crop development. With the removal of aldicarb from the peanut market, alternative strategies are needed to protect peanut yield from thrips injury. In small-plot experiments over three years, imidacloprid controlled thrips and protected peanut yield equally or more effective than phorate or acephate applied in the seed furrow at planting. In some instances postemergence applications of acephate were not needed when following imidacloprid but often increased control and yield when following acephate or phorate applied in the seed furrow. Imidacloprid was compatible with *Bradyrhizobia* applied in the seed furrow at planting as an essential component of biological nitrogen fixation and did not increase incidence of tomato spotted wilt of peanut when the tolerant cultivar Bailey was planted. The current risk index for managing TSWV has been modified to reflect use of imidacloprid in peanut.

P035 NOCTOVI : An effective food based attractant for lepidopteran pests

Rafael Borges[1], Rodrigo Oliveira Da Silva[2], Carmem Bernardi[2], William Urrutia[2], and *Agenor Mafra-Neto[2], president@iscatech.com

[1]ISCA Tecnologias Ltda, Ijui, RS, Brazil; [2]ISCA Technologies, Inc., Riverside, CA

The Noctuidae family of insects, primarily as larvae, are responsible for the largest global damage in cotton, soybean, and corn crops. Currently, with respect to these pests, there is a great need to provide tools that control adult populations as most available products target larvae, the damage causing life stage. Controlling adults is pertinent because they are the source of new pest generations, making their control a pressing need in management strategies. In response to this need, ISCA Technologies has created NOCTOVI, a volatile formulation attractive to many noctuid species. The use of NOCTOVI allows for reductions in insecticide usage, which further reduces insect resistance, environmental and food contamination, as well as health risks to workers involved with pest control. The NOCTOVI product is formulated with volatile phagostimulants that promote the consumption of the formulation by target insects and is not attractive to beneficial insects such as bees and other Hymenoptera. For population control, a small amount of insecticide is added to NOCTOVI so that the target moths die consuming the mixture, inhibiting future generations and protecting crops. NOCTOVI, with an insecticide, applied in isolated bands 50-100m apart within a crop, attracts and kills adult noctuids for at least two weeks in the field. Research from ISCA Technologies evaluates the effect of NOCTOVI applications on populations of *H. armigera* and *P. includens* in soybean plantations.

P036 Thrips management in Texas high plains cotton

Abdul Hakeem and *Megha N. Parajulee, m-parajulee@tamu.edu

Texas A&M AgriLife Research and Extension Center, Lubbock, TX

The western flower thrips, *Frankliniella occidentalis* Pergande, is a serious pest on seedling cotton in the Texas High Plains and other regions of the US Cottonbelt. Thrips are an early season pest which can cause severe damage to seedling cotton. First three weeks of seedling stage is important because thrips can cause significant damage during this period when plants are 1-3 true-leaf stage. Heavy infestations can cause leaves to shrivel and loss of leaf chlorophyll, leaf area and ultimately significant yield reduction. No-thrips cages have been useful to study thrips in the field. In a greenhouse study, 0, 0.5, 1 and 4 thrips per seedling were released at 1-2 true-leaf stage. After 22 days of release, seedlings were harvested, washed and counted thrips. Significantly higher thrips densities were observed from treatments where 1 or 2 thrips were released per seedling compared to 0.5 and control. Visual ranking values of plants from thrips densities 0 and 0.5 were significantly superior compared to that from thrips densities 1 and 2. Thrips management approaches including seed treatment, planting date adjustment, cultural control, and insecticide chemistries, and their integration will be presented.

P037 Integrated lygus management in Texas high plains cotton

Megha N. Parajulee, m-parajulee@tamu.edu

Texas A&M AgriLife Research and Extension Center, Lubbock, TX

Texas A&M Cotton Entomology research in the Texas High Plains began in 1937, but the focus on *Lygus* research was started in 2001. Our program has used *Lygus* as the model insect to answer various ecological questions in cotton pest management. In the past fifteen years, more than 20 research projects were conducted on various aspects of *Lygus* biology, behavior, and ecology. Experiments were conducted in the laboratory, greenhouse, research farms, and growers' fields. *Lygus* research conducted in our program includes host-plant survey, life table analysis, host preference, intercrop movement, feeding biology, cotton plant/*Lygus* interactions, sampling, insecticide resistance, pesticide evaluations, overwintering biology, morphology, molecular ecology, cultural control, landscape structure, and economic threshold development. Our programmatic effort on *Lygus* IPM research has resulted in some significant outcomes for further scientific investigation and for grower adoption, including alternate host identification, characterization of feeding and movement biology, pesticide spray initiation and termination rules, molecular marker development, determination of genetic structure, pesticide resistance monitoring, morphological characterization, life table investigation, and crop protection product evaluation. The Cotton Entomology Program has contributed significantly to assisting Texas cotton producers, crop consultants, Extension agents, and the scientific community by expanding our cotton pest management knowledge and skills through research and outreach.

P038 Host plant resistance as a tool to manage tarnished plant bug, *Lygus lineolaris*, in cotton in Arkansas

*Glenn Studebaker, gstudebaker@uaex.edu, Fred Bourland, and Logan Towles

University of Arkansas Division of Agriculture, Northeast Research and Extension Center, Keiser, AR

The tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois) is a major pest of cotton in the mid-Southern United States. It is not uncommon for growers to make 3-6 applications of insecticide to control this pest in a normal growing season while some may make as many as 15 applications in situations of heavy pest pressure. Insecticides have been the primary line of defense against this pest in the past. However, the tarnished plant bug is developing resistance to many of the insecticides commonly used for control of this important pest. Host plant resistance to a pest is an important component of IPM and should not be overlooked. Large plot studies verifying resistance found in small plots were conducted from 2007–2013. Results of these studies show that resistant varieties require approximately half as many insecticide applications as susceptible varieties and often do not require any insecticides until late in the season when compared to susceptible varieties.

P039 Reducing pest occurrence in cotton and soybean utilizing interseeding technology

*Michael W. Marshall[1], marsha3@clemson.edu, Ahmad Khalilian[1], Jeremy K. Greene[1], and Young J. Han[2]

[1]Edisto Research and Education Center, Clemson University, Blackville, SC; [2]Department of Agriculture and Environmental Science, Clemson University, Clemson, SC

Soybean [*Glycine max* (L.) Merr.] and cotton (*Gossypium hirsutum* L.) growers in the southern US are facing new production problems that are either reducing farm profits and sustainability or threatening soil conservation practices: 1) Herbicide-resistant weeds are spreading throughout the Southeast; 2) Tobacco thrips [*Frankliniella fusca* (Hinds)] were ranked the number two cotton insect pest in South Carolina; 3) the most effective tool for managing nematodes, aldicarb, is no longer available; and 4) fuel costs have increased significantly over the last ten years. An interseeding or relay intercropping system was developed at Clemson University which allows planting of a second crop into standing wheat, about 2-3 weeks before wheat harvest. This system which combines cover crops and minimum tillage operations has the potential to mitigate most of the production problems cited above while enhancing farm profits and soil properties. Results showed that crop residue associated with the interseeding production system reduced weed population densities and required significantly

less herbicide inputs compared with the conventional system. Columbia lance nematode (*Hoplolaimus columbus*) populations were reduced in the interseeding system by 80% without a nematicide application. *F. fusca* populations were reduced by 74% in the interseeding production system. Interseeded cotton and soybean yields were similar to conventional full season crop. Conventional production systems required 53% more fuel than interseeding system. In summary, intercropping system reduces pest problems in cotton and soybean and allows growers to capitalize on the economic advantages of two crops per year on the same land.

P040 Managing the soil seedbank with dicamba in fields with glyphosate-resistant Palmer amaranth

*M. Inman, mdinman@ncsu.edu, D. Jordan, A. York, W. Everman, and K. Jennings

North Carolina State University, Raleigh, NC

Palmer amaranth has become the most important weed to manage in cotton in North Carolina because of its biology and due to presence of biotypes expressing resistance to several herbicides including glyphosate. Dicamba-resistant cotton has been developed for postemergence weed management in cotton and soybean. Research was conducted from 2011-2014 in North Carolina to determine the value of dicamba in managing glyphosate-resistant Palmer amaranth. Approximately 10% of Palmer amaranth present in the two fields where the experiment was conducted was resistant to glyphosate prior to 2011. Including dicamba in the program with glyphosate decreased the soil seedbank and maintained the frequency of resistance at a low level during the first few years of the experiment. However, by the end of this phase of the experiment (four growing seasons) the frequency of glyphosate resistance exceeded 50% regardless of herbicide program. The increase in frequency of glyphosate resistance even when dicamba effectively controlled the vast majority of weeds most likely resulted from pollen movement from Palmer amaranth in glyphosate-only plots. Palmer amaranth population increased exponentially over the four years when glyphosate was the only herbicide applied. Pendimethalin plus diuron had modest impacts on Palmer amaranth populations when applied at planting and followed by glyphosate. While dicamba has potential to be an effective resistance management tool in cotton, long-term sustainability of this technology will be impacted by stewardship and integration into strategic integrated pest management programs for cotton and other crops.

P041 Resistance of *Ammannia arenaria* to bensulfuron-methyl and its fitness cost

*Jinwen Zhu[1], zhjw@zju.edu.cn, Bing Liu[2], Guiping Zheng[1], Jianlong Xu[3], Zhihui Tian[4], Longjiang Fan[1], and Xuexin Chen[1]

[1]College of Agriculture and Biotechnology, Zhejiang University, Zhejiang, China; [2]College of Agriculture, Northeast Agricultural University, Heilongjiang, China; [3]College of Life Science, China Jiliang University, Zhejiang, China; [4]Eco-Environmental Protection Institute, Shanghai Academy of Agriculture Science, Shanghai, China

Ammannia arenaria H.B.K. has been becoming one of the most harmful weeds in paddy rice field in China in recent years, the object was to detect the sensitivity of the weed to bensulfuron-methyl (BSM), and to compare the biological differences between resistant biotype (RB, NB143) and susceptible biotype (SB, HZ001). For the 140 biotypes tested, 96.4% of them were resistant to BSM, the average resistance index of biotypes from Zhejiang, Jiangsu, and Anhui provinces and Shanghai city were 31.3, 20.7, 6.9 and 16.8, respectively. The emergence dynamic of RB seeds were similar to SB with two emergence peaks in 2-6 and 10-12 days after seeding. The height of the RB plants was 118.0 cm, and dry weight was 34.3 g, there were 115 branches and 2198 leaves per plant, which were 26.2%, 54.5%, 59.0% and 43.8% less than those of SB, respectively. However, the early florescence time was 16 days earlier than that of SB. The results indicated that the resistance of *A. arenaria* to BSM was widely distributed in Yangtze River Delta region in China. There was fitness cost for the resistant biotype with biomass decrease, but it blossomed earlier, which might contributes to its strong environmental adaption and competition ability in paddy rice field. (The work was funded by National Natural Science Foundation of China (No.31171863), Special Fund for Agro-scientific Research in the Public Interest (201303031,201303022)).

P042 Value of deep tillage in managing Palmer amaranth in cotton, tobacco, and sweet potato in North Carolina

*M. Vann, matthew_vann@ncsu.edu, M. Inman, D. Jordan, K. Jennings, L. Fisher, and A. York

North Carolina State University, Raleigh, NC

Wide-spread presence of biotypes of Palmer amaranth expressing resistance to glyphosate and acetolactate synthase-inhibiting herbicides has required growers to diversify their weed management programs through use of a wider range of herbicide modes of actions (MOA), more frequent removal of weeds with manual labor, and implementing more intensive tillage systems in some cases. Research was initiated in 2011 and completed in 2014 to determine the value of a single deep tillage operation on subsequent populations of Palmer amaranth when herbicides considered effective in controlling herbicide-resistant Palmer amaranth were used. Hand-removal of weeds was also included to implement a zero tolerance seed production program following both primary tillage systems. Deep tillage decreased weed populations during the first year of production with the impact minimized in subsequent years. The zero seed production program minimized

Palmer amaranth populations in some but not all instances. The impact of both deep tillage and the zero tolerance seed production program had minimal impacts on economic return during the length of the experiment when effective herbicides were used to control Palmer amaranth.

P043 Winter canola in Oklahoma: Pest management challenges and solutions

*Tom A. Royer[1], tom.royer@okstate.edu, K.L. Giles[1], A.A. Zarrabi[1], J. Damicone[1], J. Bushong[2], and A. Post[2]

[1]Department of Entomology and Plant Pathology, Oklahoma State University, Stillwater, OK; [2]Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK

Canola is an economically viable winter rotational crop for Oklahoma winter wheat producers that broadens their options for management of difficult-to-control winter annual grassy weeds, delivers positive economic returns as a cash crop and provides an early season source of pollen and nectar for native and domestic pollinators. Since its introduction in 2003, canola has presented insect and plant disease pest management challenges that must be addressed with regard to minimizing deleterious effects on pollinators and natural enemies while maximizing economic return to the grower. This poster outlines several pest complexes that have arisen and the strategies that have been used to address their effective management.

P044 In-field assessment of fitness in mixed glyphosate-resistant and -sensitive populations of Palmer amaranth

*C. Cahoon[1], cwcahoon@ncsu.edu, A. York[1], D. Jordan[1], and P. Tranel[2]

[1]North Carolina State University, Raleigh, NC; [2]University of Illinois, Urbana-Champaign, IL

Research was conducted at two locations in North Carolina with native populations of Palmer amaranth (*Amaranthus palmeri*) to determine if there is a relationship between EPSPS gene copy number, an indicator of glyphosate resistance, and seed production of Palmer amaranth in presence of cotton (*Gossypium hirsutum*). Native populations of Palmer amaranth were evaluated near Clayton and Mount Olive in 2014 by allowing approximately 100 plants at each location to interfere with cotton for the entire season. Seed was collected after reaching maturity but before shattering, dried in the greenhouse and cleaned in order to determine total seed weight and subsequently seed number per plant. At Clayton, the population of Palmer amaranth was comprised of 46 male and 47 female plants. Of the male and female plants, 34 and 36 were resistant to glyphosate (EPSPS copy number > 2). At Mount Olive, 47 males and 59 females made up the entire field population. Male and female plants resistant to glyphosate numbered 29 and 35, respectively. At Clayton, glyphosate-resistant female plants produced approximately 445,000 seed compared with 630,000 seed produced by glyphosate-susceptible females ($p < 0.0001$). At Mount Olive, glyphosate-susceptible females produced 630,000 seed/plant while glyphosate-resistant plants produced 310,000 seed/plant ($p < 0.0001$). These data suggest a possible fitness penalty due to glyphosate resistance based on total seed production in the field. However, while gene copy number expressed in the female parent was known, pollination occurred from a mixed pool of male parents with respect to glyphosate resistance.

P045 Western Region IR-4: Protecting specialty crops, practicing IPM, promoting global trade

*Ronda E. Hirnyck[1], rhirnyck@uidaho.edu, Sally D. O'Neal[2], James J. Farrar[3], Rebecca Sisco[4], in cooperation with Western Region IR-4 Center and State Liaison Representatives

[1]Integrated Pest Management Center, University of Idaho, Boise, ID; [2]Irrigated Agriculture Research and Extension Center, Washington State University, Prosser, WA; [3]Western IPM Center, Davis, CA; [4]Western Region IR-4 Center, Davis, CA

The purpose of the Interregional Research #4 (IR-4) Program is to insure that producers of specialty crops and ornamental plants have adequate tools to conduct sound, sustainable integrated pest management (IPM). The Western Region IR-4 Program oversees field trials, laboratory analyses, and quality assurance protocols that result in the registration of crop protection tools for specialty crops in Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. This results in production of a greater variety of crops and sets the stage for Western agricultural producers to compete successfully in the global marketplace by practicing IPM. IR-4's evolving mission includes consideration of international maximum residue levels (MRLs) in support of US exports, attention to invasive pests, service to organic producers, and an increased focus on biopesticide products. With support from our partners at the Western IPM Center, USDA-ARS, USDA-NIFA, US EPA, the crop protection industry, and the land grant universities of the West, the Western Region IR-4 program serves specialty crop producers and food processors in the West, enabling them to serve food consumers of the US and the world.

P046 Utah fruit and vegetable IPM program and impacts

*Marion Murray, marion.murray@usu.edu, Diane Alston, and Bonnie Bunn

Department of Biology, Utah State University Cooperative Extension, Logan, UT

The Utah IPM Program serves the vegetable and fruit industries of Utah, which covers approximately 10,000 acres, in a

variety of ways. The program offers a wide array of educational components and applied research programs. The IPM pest advisory service reaches over 8,000 commercial, residential, and private applicators with free, weekly, subscription-based email alerts that contain pest biology, monitoring tips, site-specific degree days and treatment timings, threshold recommendations, and control options. An online decision aid tool and companion app called Utah TRAPs (Timing Resource and Alert for Pests) provides near real-time degree days, pest phenology, and treatment recommendations for over 50 locations. Other outreach activities include production guides, fact sheets, website, workshops, and grower meetings. Applied research that supports the Utah IPM Program's goals is focused on optimal management of pests. Projects involve the understanding of pest biology, pest management programs that focus on reduced pesticide use and profitability, pest thresholds, and predator/prey interactions.

P047 Outcomes of the Western Small Farm IPM Working Group: Constraints and prospects for IPM on small farms

*Tessa Grasswitz[1], tgrasswi@nmsu.edu, Edmund Gomez[2], Diane Alston[3], Dan Drost[4], Doug Walsh[5], Marcy Ostrom[6], Ed Bechinski[7], Cinda Williams[8], Gwendolyn Ellen[9], Cheryl Wilen[10], and Ramiro Lobo[11]

[1]Department of Entomology and Extension Plant Sciences, New Mexico State University, Los Lunas, NM; [2]Extension Economics Department, New Mexico State University, Alcalde, NM; [3]Department of Biology, Utah State University, Logan, UT; [4]Department of Plants, Soils and Climate, Utah State University, Logan, UT; [5]Department of Entomology, Washington State University, Prosser, WA; [6]Department of Community and Rural Sociology, Washington State University, Wenatchee, WA; [7]Division of Entomology, University of Idaho, Moscow, ID; [8]Latah County Extension, University of Idaho, Moscow, ID; [9]Integrated Plant Protection Center, Oregon State University, Corvallis, OR; [10]University of California Cooperative Extension, San Diego, CA; [11]University of California Cooperative Extension, San Marcos, CA

The Western Small Farm IPM Working Group was formed in 2010 with the aim of developing a regional network of effective small farm-IPM teams that, in turn, could better help the diverse small-scale producers in member states. The project plan included conducting initial needs assessment exercises in each state, followed by on-farm IPM pilot projects intended to gain a deeper understanding of, and insight into, the IPM-related needs and constraints of these producers. Some key findings and recommendations from our work include the following: (i) the most effective way to meet these farmers' needs seems to be through participatory, field-based activities; (ii) adoption of IPM on small farms is often hindered by a lack of critical inputs in appropriate pack sizes; (iii) information flow between these clients and research and extension services could perhaps be facilitated by creating small-acreage producer organizations in each state; (iv) many small-scale growers develop highly innovative pest management solutions that could usefully be disseminated to wider audiences; (v) regular visits by trained personnel to pilot-project farms resulted in the detection of various new crop pests and diseases, including several state records; given that many small farms are highly diversified (and may include various non-traditional crops), such farms could form an invaluable component of a national pest-detection network; (vi) IPM research and extension efforts in many states are still targeted mainly at large-scale agriculture and hence IPM-related services to small-scale producers are not likely to improve unless new programs are developed specifically targeted at this sector.

P048 IPM of specialty crops and community gardens in north Florida

*Muhammad Haseeb[1], Muhammad.Haseeb@famu.edu, Tavia Gordon[1], Gohar Umar[2], Dasia Harmon[1], Mathews Paret[3], Jesusa Legaspi[4], Alejandro Bolques[5], Lambert Kanga[1], and Bobby Phills[2]

[1]Center for Biological Control (CBC), College of Agriculture and Food Sciences (CAFS), Florida A&M University (FAMU), Tallahassee, FL; [2]Center for Viticulture and Small Fruits Research, CAFS, FAMU, Tallahassee, FL; [3]North Florida Research and Education Center, University of Florida, Quincy, FL; [4]USDA, ARS, Tallahassee, FL; [5]Cooperative Extension Program, CAFS, FAMU, Tallahassee, FL

Insect pests post serious challenges to specialty crops (vegetables, fruits and nut crops) and community gardens in North Florida. The major vegetable pests include., silverleaf whitefly, *Bemisia argentifolii*; the green peach aphid, *Myzus persicae*; southern green stinkbug, *Nezara viridula*; brown stink bug, *Euschistus servus*; potato aphid, *Macrosiphum euphorbiae*; leaf footed bug, *Leptoglossus phyllopus*; western flower thrips, *Frankliniella occidentalis*; melon thrips, *Thrips palmi*; eastern flower thrips, *Frankliniella tritici*; Florida flower thrips, *Frankliniella bispinosa*; tobacco thrips, *Frankliniella fusca*; southern armyworm, *Spodoptera eridania*; beet armyworm, *Spodoptera exigua*; yellowstriped armyworm, *Spodoptera ornithogalli*; pepper weevil, *Anthonomus eugenii*; kudzu bug, *Megacopta cribraria*; squash bug, *Anasa tristis*; Colorado potato beetle, *Leptinotarsa decemlineata*; leafminer; *Liriomyza sativae*, L. trifolii; tomato pinworm, *Keiferia lycopersicella*; and tomato fruit worm, *Helicoverpa zea*. Insect pests that carry diseases were considered most serious which included thrips and whiteflies. To provide necessary skills and hands-on training to stakeholders and clientele, Florida A&M University initiated an extension IPM project in 2010 to implement IPM strategies in specialty crops and community gardens. The target strategies include regular scouting or monitoring for pest problems, identifying pests & 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 if needed. Indeed, by adopting IPM strategies, participating growers in the target counties were able to produce various crops successfully. Also, undergraduate and graduate students have obtained training on crop production and protection.

P049 Development of bilingual material to facilitate early detection and control of the azalea lace bug

*Luisa Santamaria, luisa.santamaria@oregonstate.edu, and Gilbert Uribe

North Willamette Research & Extension Center, Oregon State University, Aurora, OR

The azalea lace bug is an invasive pest detrimental to the aesthetics of azaleas in Oregon. Informing the public, and nursery and landscape industries about signs and symptoms associated with the azalea lace bug is the first step in controlling their numbers and the damage they cause. To address this issue, teaching materials in the form of fact sheets and a poster were developed as standalone informational tools. Also, due to the increase in Spanish-speaking populations of the public and workforce, it was important that the material be available in both English and Spanish. The poster provides large, high quality images of the symptoms and damage caused by the azalea lace bug. It also includes photographs and information about their life cycle that would aid in recognizing azalea lace bug eggs, nymphs, and adults. The poster is weatherproof, designed to be outside, where it can be used as an educational tool. There are two fact sheets, one in English and the other in Spanish, that complement the poster, providing more detailed text about the insect, its origin, and IPM practices. These fact sheets are not direct translations of each other. Instead, the same information is presented in a manner that was most appropriate for each subset of the intended audience. The poster and fact sheets provide sufficient, up-to-date information to recognize and control azalea lace bug.

P050 iBooks: A new extension publication platform

Sarah A. White[1], *Amy Fulcher[2], afulcher@utk.edu, William Klingeman[2], Anthony LeBude[3], Frank Hale[4], Steve Frank[5], Craig Adkins[6], S. Kris Braman[7], Matthew Chappell[8], J.H. Chong[1], Jeff Derr[9], Winston Dunwell[10], Gary Knox[11], Mathews Paret[12], Joe Neal[3], Nicole Ward Gauthier[13], Jean Williams-Woodward[14], and Alan Windham[4]

[1]School of Agricultural, Forest, and Environmental Sciences, Clemson University, Clemson, SC; [2]Department of Plant Sciences, University of Tennessee, Knoxville, TN; [3]Department of Horticultural Science, North Mountain Horticultural Crops Research and Extension Center, North Carolina State University, Mills River, NC; [4]Department of Entomology and Plant Pathology, University of Tennessee, Nashville, TN; [5]Department of Entomology, North Carolina State University, Raleigh, NC; [6]Cooperative Extension Service, North Carolina State University, Lenoir, NC; [7]Department of Entomology, University of Georgia, Griffin, GA; [8]Department of Horticulture, University of Georgia, Athens, GA; [9]Department of Plant Pathology, Physiology, & Weed Science, Virginia Polytechnic Institute and State University, Virginia Beach, VA; [10]Department of Horticulture, University of Kentucky, UK Research and Education Center, Princeton, KY; [11]Department of Environmental Horticulture, University of Florida, North Florida Research and Education Center, Quincy, FL; [12]Department of Plant Pathology, University of Florida, North Florida Research and Education Center, Quincy, FL; [13]Department of Plant Pathology, University of Kentucky, Lexington, KY; [14]Department of Plant Pathology, University of Georgia, Athens, GA

Printed books are the traditional method of delivering topic-focused information to a broad audience. In this increasingly digital world, mobile devices are ubiquitous in the US and create a portable, lightweight platform for personal libraries. eBooks can be an effective resource in the Extension toolbox, facilitating delivery of text, graphical, and even video content. The Southern Nursery IPM (SNIPM) working group chose to create and publish Extension materials as iBooks because of its interactive nature, ease of use, book-layout capacity, and audience familiarity with the download interface. By using iBooks Author, we had a range of pre-developed layouts and style templates that were customizable and readily converted to .pdf and/or print versions when needed. An added benefit of an iBook is inclusion of color rich, pictorial content that supplements and enhances information presentation, especially when aiding pest and plant identification. Co-authors partnered to write and publish two iBooks "IPM for Select Deciduous Trees in Southeastern US Nursery Production" and "IPM for Shrubs in Southeastern US Nursery Production: Vol. 1". iBook readership is exclusive to those who possess Apple devices, so consideration of alternative distribution mechanisms was also important to maximize resource availability to a wider audience. Using iBooks Author simplified developing both .pdf and print versions of the book to expand accessibility, helping to effectively reach our target audience with multiple media formats. Currently, .pdf downloads well exceed the iBook downloads (approximately 5:1) for these Extension resources, underscoring the need to make these written resources available in multiple formats.

P051 MyIPM, a new smartphone app for strawberry and peach disease management

Guido Schnabel, *Mengjun Hu, mjhu1985@gmail.com, Gregory Edison, and Roy Pargas

Department of Agricultural and Environmental Sciences and Department of Computer Sciences, Clemson University, Clemson, SC

We developed a new smartphone application, MyIPM, to promote Integrated Disease Management for sustained peach and strawberry production in the southern United States. The app is available in the Google Play Store for Android phones and will also soon be available in the Apple Store for iOS devices. It features about a dozen of the most important diseases of the two fruit crops. For each disease there are pictures of signs and symptoms, descriptions of the causal agent, and a 2-min audio from the regional specialist. The app features chemical and biological control options, including a list of registered active ingredients for each disease that are sortable by FRAC codes and southeastern spray guide-published efficacy. The app also features field toxicity values as published by the Cornell IPM Program. The active ingredients are linked to registered trade names. MyIPM also features some audio recordings from regional specialists on peach and strawberry IPM issues. Our vision is that this app provides a valuable tool for growers and specialists alike that supplements current spray guides. The unique display of active ingredients, color-coded by chemical classes, provides a useful tool to promote resistance management. The app requests and allows for feedback, which should help keep the information up to date at all times. MyIPM is fed by a database that can be updated through an authoring tool. The app is currently free of charge. It is expandable to more crops and may also have potential for other disciplines, such as entomology.

P052 Role of IR-4 Ornamental Horticulture Program in developing IPM tools for specialty crops

*Cristi L Palmer, palmer@aesop.rutgers.edu, Jerry Baron, and Ely Vea

IR-4 Project, Rutgers University, Princeton, NJ

The IR-4 Ornamental Horticulture Program focuses on finding pest management solutions for specialty crop production issues, as determined at the biennial priority setting workshops, by providing efficacy and crop safety data to label new uses for disease, pest, and weed management. Protocol development occurs after priorities have been established. Tools chosen for screening must have favorable safety profiles for humans and the environment, including non-target organisms such as beneficial insects. The tools can be biologically or chemically based but must have some preliminary laboratory or field data, even from a similar cropping systems. Since the inception of this philosophy in 2005, IR-4 has screened more than 15 extracts & softer chemicals and 10 live organisms for pathogen efficacy, 20 extracts & softer chemicals and 8 live organisms for arthropod efficacy, and 8 extracts & softer chemicals for weed management. Along the way, there have been a few challenges. Biopesticides have been placed into protocols originally designed for chemically-based product screens; one product is typically applied throughout the experiments rather than testing rotation programs because it is important for registration to determine the level of efficacy of single active ingredients regardless of how they will be applied by growers. Other challenges have included initial level of inocula or infestation levels and variable environmental conditions leading to situations where biologics may not perform as anticipated. Nevertheless, IR-4 continues to improve protocol development and screening processes for new IPM tools.

P053 IPM of Oriental Fruit Moth, *Grapholitha molesta* (Busck) in peach orchards in northern China

*Rui Y. Ma[1],maruiyan2004@163.com, Zhi G. Zhao[1], Li J. Zhang[1], Wei N. Kong[1,2], and Jie Li[3]

[1]College of Agriculture, Shanxi Agricultural University, Taigu, Shanxi, China; [2]Institute of Plant Protection, Shanxi Academy of Agricultural Science, Taiyuan, Shanxi, China; [3]Institute of Promology, Shanxi Academy of Agricultural Science, Taiyuan, Shanxi, China

Oriental Fruit Moth, *Grapholitha molesta* (Busck) is a very serious pest of peach orchards in northern China. The issues of food safety and environmental protection strongly recommend scientific research to develop control techniques with the least use of chemical pesticides and encourage alternative control measures of pests. The application of Bionic pest control strategy has resulted in effective control of the pest. This strategy includes various control methods and is used for the integrated management of Oriental Fruit Moth in peach orchards in China. Bionic pest control based on synthetic sex pheromones, developed a series of safe application technologies, and mainly includes forecast and monitoring, mass trapping, and mating disruption. It is the combination of three methods in different management levels and purposes in peach orchards. A series of environmental-friendly control methods are recommended. First, avoid mixing different fruit trees when planting a new orchard. Secondly, cultivation, a physical management is also used in peach orchards to reduce orchard's overwintering fruit moth population in early spring and mid-autumn. Releasing *Trichogramma* may also decrease Oriental Fruit Moth eggs in summer. Lastly, a few biological and safe pesticides are suitable to control the fruit moths, however, this moth is still an important pest in peach orchards in northern China.

P054 Collecting baseline data to develop IPM strategies for hops in Ontario, Canada

*Melanie Filotas[1], melanie.filotas@ontario.ca, Cathy Bakker[2], and Mary Ruth McDonald[2]

[1]Ontario Ministry of Agriculture, Food and Rural Affairs, Simcoe, ON, Canada; [2]Department of Plant

Agriculture, University of Guelph, Guelph, ON, Canada

While eastern North America is not generally thought of as a major area for hop production, there was a significant industry in this area until the early 1900s, when acreage decreased dramatically due in large part to pest pressure. Recently, renewed demand for local hops from craft brewers has led to a resurgence of hop production in Ontario, with acreage increasing by 300% in the last 5 years. To support the continued growth of this industry and develop integrated pest management strategies specific to Ontario, baseline data on pest dynamics, behaviour and varietal susceptibilities was generated by scouting hopyards throughout the province in 2013-2014 for major insect and disease pests. Potato leafhoppers, Japanese beetles and two-spotted spider mites were the most common insects found, however pest levels varied dramatically with location of hop yards and cultivar. Japanese beetles were found predominantly in the southwestern part of the province, and were least severe on the cultivars Chinook, Bertwell (a naturalized selection) and Cascade. Potato leafhopper populations were found in hopyards throughout the province, with populations appearing to be influenced more by neighbouring crops than geographic location. Potato leafhopper levels also varied with cultivar, with least damage observed on Bertwell, Galena and Centennial. Downy mildew and Alternaria cone disorder were the predominant diseases found in 2013-2014. While there were no statistical differences between cultivars in downy mildew severity, Galena was observed to have more basal spikes. Alternaria was less severe on Cascade and Bertwell.

P055 Impact of applications of copper containing pesticides on earthworm communities in viticulture

*Bernd Hommel[1], bernd.hommel@jki.bund.de, Dieter Felgentreu[1], Nadine Herwig[1], Jörn Strassemeyer[2], and Thomas Strumpf[1]

[1]Julius Kühn-Institut, Federal Research Centre for Cultivated Plants (JKI), Institute for Ecological Chemistry, Plant Analysis and Stored Product Protection, Berlin, Germany; [2]JKI, Institute for Strategies and Technology Assessment, Kleinmachnow, Germany

On one hand, the importance of copper-containing pesticides as efficient fungicides in organic farming and for resistant strategies in integrated farming is without any doubt. However, on the other hand, these types of pesticides give cause for serious environmental concern. Therefore, the European Union (EU) has authorized copper as a pesticide only until January 2018. The corresponding EU directive 2009/37 states: "Member States shall initiate monitoring programmes in vulnerable areas where the contamination of the soil compartment by copper is of concern, in order to set, where appropriate, limitations such as maximum application rates." In 2010, Germany started activities to develop a "copper minimizing strategy" in specialty crops (grape, hop, apple). Current results in viticulture are presented at the 8th IPM symposium in Salt Lake City in 2015: The total and mobile copper content, other soil parameters and the status quo of earthworm communities were determined in different German viticultural areas over the period 2010-2014. The results demonstrate that soils' total copper content ranges from 10 to 325mg kg-1 soil dry matter, therefrom the mobile content is less than 1%. A trend that high mobile copper compounds negatively influence on earthworm communities was found. But, these effects could be strengthened or weakened by other environmental influences, e.g. pH value, organic matter, texture or agricultural management measures. There are fields with high copper contents, mainly caused by decades of spraying copper as a pesticide, where earthworm communities are well developed. Their benefits to ecosystem services in viticulture will be investigated subsequently.

P056 Chemical ecology of spotted wing drosophila

*Neil Kirk Hillier[1], kirk.hillier@acadiau.ca, Cate Little[2], Heather Crozier[1], Tom Chapman[2], Peggy Dixon[3], and Debra Moreau[4]

[1]Department of Biology, Acadia University, Wolfville, NS, Canada; [2]Department of Biology, Memorial University of Newfoundland, St. John's, NL, Canada; [3]Atlantic Cool Climate Crop Research Centre, Agriculture and Agri-Food Canada, St. John's, NL, Canada; [4]Atlantic Food and Horticulture Centre, Agriculture and Agri-Food Canada, Kentville, NS, Canada

Spotted wing drosophila (*Drosophila suzukii*) is an exotic invasive that has spread rapidly throughout the US and Canada since its first N. American identification in California in 2008. *D. suzukii* lays eggs in a wide range of ripening soft-skinned fruit resulting in significant losses in crop yield and quality. This study investigates alternative attractants to improve monitoring for *D. suzukii*. Currently monitoring methods using baited traps are not effective for early detection (low population densities) of *D. suzukii*, and moreover attract significant non-pest bycatch. We will improve this monitoring strategy through an examination of *D. suzukii* olfactory sensitivity and odor preference. The overall objective of this study will be to improve the technology for detection and management of this invasive species. Experimentally, this will be addressed through behavioural and electrophysiological assays of *D. suzukii* olfactory preference, and through field testing of novel lures in trapping assays. This research will provide a range of benefits to the soft fruit industry, specifically an improved monitoring technology to identify and quantify *D. suzukii* populations in North America to forecast need for pesticide application.

P057 Managing a new threat to berry crops through local and regional cooperation

*David T. Handley[1], david.handley@maine.edu, and James F. Dill[2]

[1]University of Maine Cooperative Extension, Monmouth, ME; [2]University of Maine Pest Management Office, Orono, ME

Spotted wing drosophila (*Drosophila suzukii*) was first found in Maine in the fall of 2011. This is an invasive pest originating in northern Asia, which can destroy the fruits of berry crops. During the winter of 2011-2012 an intensive educational program was initiated to increase grower awareness of this pest in Maine. Local efforts were supported and enhanced through cooperation with programs across the Northeast. New England research and Extension specialists developed a network of monitoring sites, maintained with the help of farmers and students. Fly population and damage data was shared with growers through a blog and mapping web page, as well as weekly e-mail updates. Management recommendations based on the results of ongoing regional research were distributed via newsletters, web pages and videos. Prior to the growing season, detailed fact sheets on identification, monitoring and management were made available through a cooperative effort with Pennsylvania State University. Although damage from spotted wing drosophila since its arrival in Maine has been significant, program surveys found that most growers were aware of the pest within the first year of its arrival and have access to management information. Extension is cited as the primary source of information regarding this insect. The impact of this program in preventing spotted wing drosophila from causing severe economic harm to Maine berry growers could not have been achieved without the cooperation of Extension and research specialists locally, regionally and nationally, enabling us to develop an effective program in a very short time.

P058 Optimizing IPM programs for spotted wing drosophila in blueberries

Ashfaq A. Sial, ashsial@uga.edu

Department of Entomology, University of Georgia, Athens, GA

Spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) is an insect pest of Asian origin and has expanded its range worldwide over the past 4-5 years. It has recently emerged as a major pest of small and stone fruits in the United States causing significant crop losses as high as 100%. Management is achieved primarily through preventative insecticide applications. Growers make as many as twice weekly applications to protect berries from SWD infestation, which may not be possible without achieving complete coverage of all surfaces of the berries. Blueberry growers employ a wide range of technologies to apply insecticides but the level of coverage achieved by those specific technologies has yet to be evaluated. In order to optimize effectiveness of insecticide applications against SWD, it is extremely important to understand the level of coverage achieved by those technologies and whether or not it is sufficient to protect fruit from SWD infestation. We conducted studies to compare spray coverage achieved by sprayers most commonly used by blueberry growers, residue deposition on the fruit, and effectiveness of the spray residues against SWD. Spray coverage was uneven in different sections of the blueberry bush canopy in all treatments. The electrostatic sprayer deposited less residues on the fruit surface and resulted in lower mortality of SWD adult flies in semi-field bioassays as compared to airblast, air cannon, and overhead boom sprayer. Implications of these results for SWD management will be discussed.

P059 Integrated management of Asian citrus psyllid using organic insecticides and parasitoids

*Jawwad A. Qureshi, jawwadq@ufl.edu, and Philip A. Stansly

University of Florida-IFAS, Southwest Florida Research and Education Center, Immokalee, FL

Management of Asian citrus psyllid (ACP) *Diaphorina citri* is critical in all habitats including organic citrus for area-wide suppression of this pest and its vectored huanglongbing (HLB) or citrus greening disease. Organic growers struggle most with the management of ACP because they are not permitted to use synthetic insecticides common in conventional production. We are investigating ACP control programs using organic insecticides and *T. radiata* also suitable for conventional citrus and urban habitats. Pyganic (natural pyrethrum) alone and with 2% 435 oil or 2% Citru-Soy™ sprayed in Nov, Dec and Jan was compared to a single spray of the synthetic pyrethroid Danitol (fenpropathrin) in Jan to control ACP in Valencia and Hamlin oranges. Only Pyganic + 435 oil and Danitol held ACP to 0.1 adults per tap sample for 4-5 weeks after the Jan application. Significant suppression of ACP in organic citrus comparable with conventional citrus was also observed during the growing season with Entrust, (Spinosad), Grandevo (*Chromobacterium substugae*), MBI 206 (*Burkholderia* spp), 435 oil, Citru-Soy™ and Pongamia oil. Parasitism of 9-100% by *T. radiata* was observed in organic citrus. Monthly sprays of Pyganic with 435 oil in winter and organic insecticides with oils and *T. radiata* in the growing season appear to be viable options for developing ACP management programs in organic citrus and area-wide.

P060 Host choice behavior based on sex in *Diaphorina citri* (Hemiptera: Liviidae) on citrus varieties

*Gustavo R. Alves[1], gralves@usp.br, Vitor H. Beloti[1], Franciele Santos[1], Kenya M. Faggioni[1], Sérgio A. Carvalho[2], José M. S. Bento[1], Pedro T. Yamamoto[1]

[1]Department of Entomology and Acarology—ESALQ/USP, Piracicaba, São Paulo, Brazil; [2]Citrus Center—Sylvio Moreira, IAC—APTA, Cordeirópolis, SP, Brazil

The Asian citrus psyllid (ACP), *Diaphorina citri* is the main vector of bacteria associated with Huanglongbing (HLB) that is considered the most important citrus disease in the world. The choice process and acceptance of the host for feeding, in which ACP selects the most suitable hosts basing on chemical and visual cues, play a key role in this choice. This study evaluated the effect of volatile compounds released by different citrus varieties on the host selection behavior of ACP. Varieties tested were 'Ponkan' mandarin (*Citrus reticulate*); 'Pera', 'Hamlin' and 'Valencia' sweet orange (*C. sinensis*) and 'Sicilian' lemon (*C. lemon*). Bioassays using olfactometer in 'Y' were conducted. Air flow was pulled by a vacuum pump and connected to the olfactometer, allowing the passage of air to the tube side and the arrival of the odors to the main tube, where the psyllids were released. The treatments were composed by combination of the varieties in pairs exposed to male or female ACP. The experimental design was completely randomized with 40 replications, with insects and plants changed every one (1) and ten (10) replications, respectively. Fifteen-day-old male and female ACP were reared on orange jasmine (*Murraya paniculata*). Only females showed a differential response between varieties confronted. Among the combinations, 'Pera' and 'Valencia' varieties were more attractive when confronted with 'Hamlin', and also 'Valencia' vs. 'Sicilian' lemon. The results suggest that all tested hosts each have attractive volatile compounds and the ACP has a different behavior for citrus variety choice based on sex.

P061 Attract-kill strategy for *Diaphorina citri* control: Selection of insecticides to apply in curry leaf

*Vitor H. Beloti, vitorblt@hotmail.com, Gustavo R. Alves, Kenya M. Faggioni, and Pedro T. Yamamoto

Entomology and Acarology Department, ESALQ/USP, Piracicaba-Sao Paulo, Brazil

Currently, the management of Huanglongbing (HLB) or Greening disease in citrus orchards is based on the chemical control of the insect vector *Diaphorina citri*, realized through intensive applications of pesticides, which has caused outbreaks of secondary pests and elimination of the natural enemies. This research aimed to evaluate the effect of thiamethoxam (Actara® 250 WG: 0.25 g a.i. pl-1) and imidacloprid (Provado® 200 SC: 0.34 g a.i. pl-1) to manage the psyllid in curry leaf (*Murraya koenigii*) for use as trap crop. The control treatment consisted of water. Adults of *D. citri* were confined on the plants 7, 14, 21 and 28 days after spraying (DAS), using cages made with voile fabric to prevent the escape of insects. The mortality was assessed at 1, 3 and 7 days after the confinement (DAC), determining the residual period and efficiency of the insecticides applied in curry leaf. Both products caused high mortality of adults up to 35 DAS, when thiamethoxam caused 100% mortality and imidacloprid 93.3%. In the first evaluation after each confinement, mortality from both insecticides was low, not exceeding 33%, showing that the insects need to feed longer to die. Thus, it is concluded that these neonicotinoids can be applied on the curry leaf to control *D. citri*, used as trap crop in an attract-and-kill strategy.

P062 Acaricidal activity of an annonin-based commercial biopesticide against citrus red mite

Odimar Z. Zanardi[1], Cynthia R. O. Jacob[1], Aline A. Franco[1], Leandro P. Ribeiro[2], Kenia F. A. Santos[1], José D. Vendramim[1], and *Pedro T. Yamamoto[1], pedro.yamamoto@usp.br

[1]Department of Entomology and Acarology, "Luiz de Queiroz" College of Agriculture/University of São Paulo (ESALQ/USP), Piracicaba, São Paulo, Brazil; [2]Research Center for Family Agriculture, Agricultural Research and Rural Extension Company of Santa Catarina (CEPAF/EPAGRI)—Chapecó, Santa Catarina, Brazil

Acetogenins are a class of natural compounds found in some Annonaceae species with promising insecticidal/acaricidal properties. These compounds are potent inhibitors of electron transport systems in the mitochondria, reducing the ATP levels in the cells causing the death of the target arthropods. However, few studies had been performed in order to assess the bioactivity of acetogenin-based biopesticides on mites that occur in fruit crops. Therefore, this study evaluated, by topic + residual contact bioassays, the bioactivity of an annonin-based commercial formulation (Anoson® 1.0 EC) against the citrus red mite, *Panonychus citri* (McGregor) (Acari: Tetranychidae), an important pest of citrus in Brazil. For this purpose, arenas made from Valencia orange leaves were infested with 10 newly emerged mite females and sprayed with solutions (2 mL) at different concentrations (0, 0.25, 0.5, 1, 2, 4 and 8 mL of formulation L-1) in a Potter tower. For each treatment, five arenas with two replicates over time were used, and the mite mortality assessment was performed daily until the fourth day. The tested biopesticide caused high mortality of *P. citri* (LC50 = 13.47, 0.84, 0.70 and 0.63 mL L-1, after 24, 48, 72, and 96 h of exposure, respectively) in a concentration-dependent way. Moreover, the biopesticide also reduced significantly the number of eggs laid per female (EC50 = 2.87 mL L-1), but did not affect *P. citri* female fertility. Thus, our results indicate that Anoson® 1.0 EC is a useful component in the framework of citrus red mite IPM in citrus and elsewhere.

P063 Impact of imidacloprid and kaolin clay on whitefly, natural enemies, and honey bee visitation

*Vonny M. Barlow[1], Vmbarlow@ucanr.edu, Joan M. Leong[2], Jacob M. Cecala[2], and Stephanie M. Duenas[2]

[1]Division of Agricultural and Natural Resources, University of California, Blythe, CA; [2]Biological Sciences, California State Polytechnic University, Pomona CA

The primary pest of melons in the desert valleys of southeastern CA is the silverleaf whitefly, *Bemisia tabaci* Gennadius, which vectors Cucurbit yellow stunting disorder virus, a crinivirus. Management of the silverleaf whitefly is typically done with a soil application of a neonicotinoid insecticide at planting. Use of neonicotinoid materials may cause decreases in natural enemy and bee pollinator assemblages in treated crop fields. We examined whether the use of neonicotinoids influences the abundance of insect natural enemies and bee floral visitation in commercially grown watermelon. The experimental treatments were: 1) a neonicotinoid insecticide applied at planting (imidacloprid), 2) a kaolin clay particle film applied every 14 d, and 3) untreated controls. Assessment of whitefly and natural enemy numbers were quantified in each treatment every 7 d. Bee activity within treatments was quantified by measuring floral visitation activity at female and male flowers and by measuring single visit duration times at individual flowers. The neonicotinoid and kaolin clay particle film treatments did not significantly affect the abundance of whiteflies. Natural enemies (*Hippodamia convergens*, lacewings, parasitoids) were also not significantly affected by treatments. Honey bee, *Apis mellifera* (Hymenoptera: Apidae) floral visit frequencies were not significantly different among the treatments. Honey bee visit duration times were similar between treatments as well. End of season results showed no difference in average melon yield between treatments but there was a difference in average melon weight in the neonicotinoid treatment. The use of kaolin clay particle film as a reduced risk alternative to neonicotinoids on watermelon did not appear to interfere with floral visitation by honey bees or natural enemy abundance.

P064 Relating shade level and altitude with occurrence of *Hypothenemus hampei* and parasitoids on coffee

Anthony R. Ijala[1], *Jeninah Karungi[1], jkarungi@caes.mak.ac.ug, Mattias Jonsson[2], Samuel Kyamanywa[1], and Barbara Ekbom[2]

[1]College of Agricultural and Environmental Sciences, Makerere University, Kampala, Uganda; [2]Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden

The diversity and abundance of natural enemies of insect pests is often higher in agroforestry plantations than in sun-exposed monocultures, and it is often assumed that this will lead to improved pest suppression. The effect that incorporating trees in cropping systems will have on pest populations, however, also depends on the habitat requirements of the pests themselves. In Eastern Uganda, we studied how shading level (full at >50 trees per acre, moderate at 21–50 trees per acre, and low at 0–20 trees per acre) and altitude (high from 1,717–1,840 m.a.s.l. and low from 1,511–1,605 m.a.s.l.) influenced the abundance of *Hypothenemus hampei* (Curculionidae). The study covered 30 coffee plantations. The pest was more common in berries from coffee plants under sun-exposed conditions. We found four parasitoids of *H. hampei*: *Prorops nasuta* (Bethylidae), *Cephalonomia stephanoderis* (Bethylidae), *Phymastichus coffea* (Eulophidae) and *Heterospilus coffeicola* (Braconidae). Generally, there was a higher occurrence of the parasitoids at higher levels of shade, and at high altitude. There was an interaction of shading level and altitude for *P. coffea* and *H. coffeicola* occurrence. This implies that the impact of agroforestry on *H. hampei* regulation both under current conditions and in a global warming scenario will be dependent not only by factors at the local scale but also at the landscape level.

P065 Use of Puffer® pheromone aerosol dispensers for mating disruption in orchards

*Loys Hawkins[1], lhawkins@suterra.com, and Daniel Casado[1,2]

[1]Suterra LLC, Product Development and Technical Support Department, Bend, OR; [2]University of California Berkeley, Environmental Science, Policy and Management, Berkeley, CA

Puffers® are mechanical devices loaded with aerosol formulations of sex pheromone for season-long mating disruption, releasing a metered volume of active ingredient at electronically-controlled intervals and, independent of weather conditions, can be restricted to operating during the period of the day that target pests are sexually active. Puffers® are applied to orchards at a rate of 2-5 units per hectare, while conventional hand-applied reservoir dispensers are applied at 250 units per hectare or higher, allowing growers to significantly reduce labor costs when implementing mating disruption. Labor savings were quantified over a two year period, and the Manufacturer's service program has increased that savings to 72-73%. Use of the technology is well established and spreading, especially in the US, but also in Europe, South Africa and South America. Puffers® have been used for control of *Cydia pomonella* (codling moth) since 1996, *Amyelois transitella* (navel orangeworm) since 2001, and *Grapholita molesta* (oriental fruit moth) since 2003. Numerous field trials demonstrated that Puffers® provide equivalent control of those pests as compared to hand-applied reservoir dispensers. Despite widespread adoption and proven efficacy of Puffers®, the exact mode of action toward the target pest is still debated. Tests conducted in pear orchards by UC Berkeley researchers indicated that a single Puffer® strongly reduced codling moth trap captures over several hectares, and at distances over 300 m downwind. Impacts included delay and frequency of trap finding (Casado et al., 2014.) Puffer® aerosol technology can enhance implementation of mating disruption while maintaining efficacy and reducing labor costs.

P066 Prionus beetle mating disruption and lure evaluation in Utah sweet cherry orchards

*Michael G. Pace[1], mike.pace@usu.edu, and Diane Alston[2]

[1]Utah State University Extension, Brigham City, UT; [2]Utah State University, Logan, UT

California prionus beetle [*Prionus californicus* (Coleoptera: Cerambycidae)] larvae have been identified as a serious pests of mature sweet cherry trees in Northern Utah. The females lay eggs in the soil near the base of the host trees where they hatch and feed on the roots of the trees for the next 3-5 years. This feeding on the tree roots causes decreased nutrient uptake, water stress, reduced growth, tree decline and mortality, eventually reducing orchard longevity. Adult males are strongly attracted to a volatile sex pheromone, (3R,5S)-3,5-dimethyldodecanoic acid, produced by females. Earlier research has shown bucket traps to be highly effective in catching the adult male beetles over panel traps. Four years of mating disruption trials with an experimental dispenser (Pacific Biocontrol Corp.) in sweet cherry orchards of northern Utah found trap shutdown rates of 88-99% when compared to the control orchards at dispenser application rates of 50 and 100 per acre (124 and 247 per hectare). Two commercially available pheromone lures, Contech (30 mg pheromone) and Alpha Scents (10 mg), caught more males than a new Isomate lure. Lures performed equally well when deployed for 4 and 8 weeks. Mating disruption and mass trapping provide viable management options for this root boring pest.

P067 IPM and technology—Digital insect trap for monitoring lepidopteran pests in orchards

*Greg Krawczyk[1], gxk13@psu.edu, Brian L. Lehman[1], Johnny Park[2], and Larry A. Hull[1]

[1]Penn State University, Department of Entomology, Fruit Research & Extension Center, Biglerville, PA; [2]Spensa Technologies, West Lafayette, IN

The use of sex pheromone-baited insect traps for precise pest monitoring is critical towards implementation of effective IPM programs. Automation of insect monitoring has the potential to significantly reduce manual labor costs for traps maintenance. During last few seasons we evaluated an automated pest detection system using bio-impedance-based electronic sex pheromone prototype traps (Z-Trap). The evaluations were aimed at determining the accuracy and reliability of traps, wireless communication system and the functionality of a web-based user interface program. A single Z-Trap system consists of traps, a wireless communication device to communicate captures to a base station, and a web based user interface (www.mytraps.com) where collected information can be viewed, stored and analyzed. After each capture, the algorithm is applied to the signal to determine whether it was caused by a target insect species. Daily insect capture data is sent wirelessly to a base station, which uploads the data to a web interface, specific for each single location. During field trials the Z-Traps for monitoring codling moth and Oriental fruit moth were deployed throughout commercial orchards in south-central Pennsylvania. Each Z-Trap was deployed with a corresponding standard large plastic delta trap placed nearby. Regular pheromone traps generally captured higher cumulative numbers of moths than the Z-Traps throughout the season. However, the trends between both types of traps were consistent. Further development of the Z-trap will require an improvement in the accuracy of moth detections to reduce the false detection rate and to increase moth identification accuracy.

P068 Insect identification using laser and wing beat frequency

*Margot Mafra-Spencer[1], margotmafra@gmail.com, Yanping Chen[2], Gustavo Batista[3], and Eamonn Keough[2]

[1]John W North High School, Riverside CA; [2]Department of Computer Science and Engineering, University of California, Riverside; [3]University of Sao Paulo, Sao Paulo, Brazil

Wing beat frequencies (WBF) of three species of insects were recorded using a photoelectric system that tracks vibrational frequencies of objects in between a common laser and photoelectric diodes. The wing beat frequencies of a mosquito *Aedes aegypti* (AeA) and two closely related species of fruit flies, *Drosophila melanogaster* (DMel) and *Drosophila suzukii* (DSuz) were collected. Approximately 150 insects of three species were placed into photo transmitter cages and monitored with recording devices for 2-3 days, and WBF analyzed. The three species insects tested have shown to have an average species-specific wing beat frequency that allows for separation of species: AeA=433.0504Hz, DMel=223.5633Hz, and DSuz=226.2800Hz. These results indicate that it may be possible to create an automatic trap that will monitor the WBF of the insects captured and provide identification of the insects inside. This will allow farmers to have updated information on what pests are currently infesting their crops, thus allowing them to better manage them. Despite the two Drosophila species having overlapping wing beat frequencies, we might be able to identify between insects in the same genus by separating them using their circadian rhythms, allowing the grower to determine whether they have the pest DSuz in their crops or a simply a benign DMel. These two species are extremely difficult to separate visually and by using their wing beat frequency, but by paring the information on their circadian rhythms and geographical locations, we may be able to identify between the two more easily.

P069 Changes in soil moisture modulate the beneficial and harmful microbial populations in avocado crops

*J.G. Ramirez, jgramireg@unal.edu.co, and J.G. Morales

Universidad Nacional de Colombia sede Medellín, Departamento de Ciencias Agronómicas, Medellín, Colombia

The avocado root rot has been called a wilt complex, a disease caused by biotic or abiotic factors. Its occurrence is closely linked to climatic factors, where precipitation and subsequent accumulation of water in the soil profile are essential for the expression of its pathogenic potential. This condition causes avocado plants to be an excellent experimental model for evaluating impacts associated with climate variables. The objective of this study was to determine the relationship between climate, plant, and microorganisms as a fundamental basis to prevent, minimize and mitigate the adverse effects of this disease. Avocado crops had weather stations positioned to monitor climate and soil factors. Meanwhile quantification was performed in time populations of beneficial and harmful microorganisms, which are also variables associated with the development of avocado plants. The results of this research show that soil moisture is a modulator of soil microorganisms whose dynamics depends on two factors: precipitation and subsurface soil dynamics associated with different properties within the profile. This study identified that excessive soil moisture levels increase inoculum associated with wilt pathogens and decreasing beneficial populations associated with groups like *Pseudomonas* spp., *Thichoderma* spp., and others. This work allows us to understand how changes in precipitation can affect soil microbial dynamics and how they alter the plant health of avocado.

P070 Approximate mathematical model for predicting avocado wilt based on climatic variables

*J.G. Ramírez, jgramireg@unal.edu.co, and J.G. Morales

Universidad Nacional de Colombia sede Medellín, Departamento de Ciencias Agronómicas, Medellín, Colombia

The avocado wilt complex is the most limiting disease of avocado cultivation in the world. It is considered that the incidence, severity and dispersion is influenced by edaphoclimatic variables especially precipitation. The objective of this study was to predict the presence of the wilt complex based on a mathematical model associated with climatic variables. In an experimental batch of 4.5 Ha, we recorded the incidence, severity and spread of wilt for a period of five years. Variables related to climate, topography of the land and associated crop management were also determined. With the data obtained, multiple correlation analysis was performed and the model was identified that presented better performance in predicting the incidence and severity of the disease. From this, another model was developed in which only climatic variables were incorporated. The presence of the disease in the batch tested for the actual behavior of developed models was performed in the software package geoR. The complete mathematical model presented a predictive value of avocado wilt superior to 90%. In comparison, the model developed from climatic variables, the only variables found to be significant were precipitation, whose predictive value was greater than 70%. These results indicate the importance of rainfall and climatic variables associated with the incidence and severity of avocado wilt, where the model developed with a higher percentage explains the dynamics of these two variables.

P071 Mitigation of climate variability in avocado crops

*J.G. Ramirez, jgramireg@unal.edu.co, and J.G. Morales

Universidad Nacional de Colombia sede Medellín, Departamento de Ciencias Agronómicas, Núcleo El Volador, Medellín, Colombia

Avocado cultivation in Colombia has seen a rapid growth, especially in moderate cold weather. Planting was not based on technical parameters, so there are serious technical limitations that make this production system unsustainable over time. Among the major limitation is the wilt disease caused by biotic or abiotic factors. The occurrence of this disease is closely linked to climatic factors, where precipitation and subsequent accumulation of water in the soil profile is necessary for the development and spread of microorganisms involved, besides the effect on the host, which is very susceptible to the conditions of hypoxia and anoxia. The objective of this study was to evaluate different strategies for mitigating the adverse effects associated with climate variability and especially associated with precipitation. It is also evaluated alone and in combination with native materials, mulches and parameters associated with the production of seedlings and planting in the field. The results so far indicate that native *Persea americana* materials have different levels of tolerance to excess soil moisture, plus vegetable toppings are an excellent strategy to respond to sudden changes in climate-related variables. Moreover adequate production of seedlings and planting in the field decreases the susceptibility of this plant to the adverse effects of climate. This work is the first approach in Colombia on evaluating alternatives to mitigate climate change in the cultivation of avocado.

P072 Insights into the epidemiology of grapevine leafroll disease in cool-climate viticulture

Bhanupriya Donda[1], Sandya Kesoju[2], Neil McRoberts[3], and *Naidu Rayapati[1], naidu.rayapati@wsu.edu

[1]Department of Plant Pathology, Washington State University, Irrigated Agriculture Research and Extension Center, Prosser, WA; [2]USDA-IAREC, Prosser, WA; [3]Department of Plant Pathology, University of California, Davis, CA

Grapevine leafroll disease (GLD) is a complex viral disease affecting wine grapes (*Vitis vinifera*). It produces distinct symptoms in red- and white-berried vinifera grapevines. Several morphologically similar but serologically and genetically distinct viruses, called grapevine leafroll-associated viruses (GLRaVs) and numbered serially as GLRaV-1, -2, -3, etc., have been documented in grapevines. Of these, six GLRaVs were reported in Washington vineyards with GLRaV-3 as the most prevalent in several vineyards. The grape mealybug (*Pseudococcus maritimus* Ehrhorn) vectoring GLRaV-3 is the only species currently reported in Washington vineyards. We monitored Cabernet Sauvignon and Syrah blocks, planted with clean stock adjacent to GLD-infected old blocks, to study spatial and temporal dynamics of GLD. Individual vines in these blocks were monitored for GLD symptoms each season between 2007 and 2014. Symptomatic and non-symptomatic vines on either side of symptomatic vines were tested by RT-PCR for the presence of GLRaV-3 to determine the viral status of symptomatic and non-symptomatic vines. The data showed increased number of symptomatic, GLRaV-3 positive vines during each season in Syrah and Cabernet Sauvignon blocks. However, higher incidence of GLD annually was observed in Syrah block compared to Cabernet Sauvignon block. The spatial and temporal analysis of symptomatic vines in both blocks indicated that the primary spread is likely occurring from heavily infected neighboring old blocks. Further, GLD spread showed aggregation/clustering of symptomatic vines within young plantings indicating secondary spread of the disease between vines. The results provided valuable insights on the epidemiology of GLD for implementing disease control measures.

P073 Control effect of velvet bean seed extract against root-knot nematode, *Meloidogyne* spp.

*C. K. Shim, ckshim@korea.kr, M. J. Kim, Y. K. Kim, S. J. Hong, J. H. Park, E. J. Han, and S. C. Kim

Organic Agricultural Division, National Academy of Agricultural Science, Rural Development of Administration, Wanju-gun, Rep. of Korea

One of the techniques for the management of coffee root-knot nematode is the use of plant extracts that have nematicidal effect. In this study, the anti-nematode activity of water extract of velvet bean [*Mucuna pruriens*] seed has been investigated against coffee root-knot nematode (*Meloidogyne* sp.) in the laboratory. Experiments were carried out with extract, concentration and time level using randomized complete design in vitro. For this purpose, the effect of water extract of velvet bean seed with concentrations of 0, 0.15, 0.3, 0.6, 1.2, and 2.4% (w/v) on the percentage of immobility of second stage juveniles was evaluated. The results indicated that all concentrations of water extract of velvet bean had anti-nematode activity. Overall water extract of velvet bean had the most effect on immobility of second stage juveniles of nematode in vitro.

P074 IPM in the Whole Foods Market Responsibly Grown Rating System

*Emily Ciesielski[1], eciesielski@ipminstitute.org, Ariel Larson[1], Matthew Doyle Olson[1], Thomas Green[1], Robin Foster[2], and Matt Rogers[2]

[1]IPM Institute of North America, Inc. Madison, WI; [2]Whole Foods Market National Produce & Floral Procurement Office, Watsonville, CA

The Whole Foods Market Responsibly Grown Rating System (rating system) for fresh produce and flowers launched in stores October 2014. The rating system is a points-based index covering a range of topics in sustainable agriculture including advanced pest management, soil health, energy and water use, farm worker welfare and ecosystems and biodiversity. Sustainable practices are based on the best available science. Participating Whole Foods Market suppliers are recognized for the sustainable practices they've implemented and may earn a rating of "Good," "Better" or "Best." Ratings are displayed in stores and customers are able to use that information to inform their purchasing. Integrated Pest Management (IPM) is an important aspect of sustainable agriculture and plays a key role in the rating system. Suppliers are recognized for practices such as identifying and implementing strategies to reduce pest pressure without use of pesticides, knowledge about key pests including lifecycles, making pesticide applications based on monitoring or inspection, reducing risks associated with pesticide use, implementing strategies to mitigate the development of pesticide resistance, practices that improve soil health and practices that encourage the persistence of native species including beneficial insects. As new science becomes available and the rating system is updated over time, elements of IPM will continue to be recognized as important components of sustainable agriculture.

P075 The Southern IPM Center's signature programs

*Danesha Seth Carley[1], danesha_carley@ncsu.edu, Rosemary D. Hallberg[1], James R. VanKirk[1], Joseph LaForest[2], Henry Y. Fadamiro[3], Robin Boudwin[1], Jean-Jacques Dubois[1], and Alex Belskis[1]

[1]Southern IPM Center, North Carolina State University, Raleigh, NC; [2]Center for Invasive Species and Ecosystem Health, University of Georgia, Tifton, GA; [3]Auburn University, Auburn, AL

The mission of the Southern IPM Center (SIPMC) is to foster the development and adoption of Integrated Pest Management (IPM), a science-based approach to managing pests in ways that

generate economic, environmental and human health benefits. SIPMC goals reflect broader goals of IPM as expressed in the National IPM Roadmap: to sustain and enhance environmental, economic and human health by applying IPM in all appropriate settings. SIPMC entails partnership across the Southern Region (13 states and 2 territories) to address research, education and public policy issues on many settings across the entire region in national collaboration with other Regional IPM Centers, public agencies and many other stakeholders. This poster will detail some of SIPMC's signature programs and how we leverage the unique strengths of three institutions in partnership with stakeholders from agricultural, urban and rural settings to identify and address regional priorities for research, education and outreach. Some of the programs we will highlight include the Southern IPM Roundtable, the IPM eAcademy, the Regulatory Information Network, and our four signature food security programs.

P076 IPM Voice advocates for progressive IPM

*Thomas Green, ipmworks@ipminstitute.org, and Alisha Bower

IPM Voice, Inc., Madison, WI

IPM Voice incorporated in 2011 to advocate for progressive IPM, focusing initially on key policymaker education. With collaborators, IPM Voice worked successfully to reinstate funding for the USDA Regional IPM Centers. Currently the organization is pursuing opportunities to broaden outreach, including to the general public to overcome low levels of science literacy, increase awareness of IPM approaches and benefits, and improve adoption of and public support for IPM. Key messages include IPM benefits in reducing risks to human and environmental health, and improving economics in agriculture and communities. IPM Voice members receive a monthly newsletter spotlighting current events in IPM research and implementation, and public policy and awareness.

P077 Using trade journals to promote IPM tools for managing weeds problematic to agriculture in Nevada

Brad Schultz and *Jay Davison, davisonj@unce.unr.edu

[1]University of Nevada Reno, Cooperative Extension, Winnemucca, NV; [2]University of Nevada Reno, Cooperative Extension, Fallon, NV

A formal needs assessment survey related to the IPM Program in Nevada identified two critical needs: 1) the identification of the highest priority weeds in each County and 2) the need for knowledge regarding effective control methods for these weeds. The first need was met using a program titled "Weeds to Watch" in which the highest priority weeds for each of Nevada's 17 counties were identified and publicized using various media. This program is part of the current effort to meet the second need. In this three year program, which began in 2013, one of the 25 weeds of highest concern to agricultural producers is featured in a monthly article published in the top two agriculture magazines in Nevada. Each article includes a series of color photographs of the target weed, a paragraph on the typical habitat where the plant is found, a section discussing plant biology, and an extensive discussion of recommended control approaches including cultural, mechanical, biological and herbicidal methods when appropriate. Each article was distributed in 9000 print copies and potentially viewed by approximately 30,000 electronic hits each month. This program represents a partnership between University of Nevada Cooperative Extension (UNCE) and two private media companies with UNCE obtaining widespread distribution of educational materials and the media companies providing their readers desired articles at no cost. A formal evaluation effort is planned following the conclusion of this program to determine the educational impact and contribution to advancing the goals of the IPM program in Nevada.

P078 Developing volunteer survey networks through interagency first detector training

Amanda C. Hodges[1], *Carla Calvert Burkle[1], burkle@ufl.edu, Leroy Whilby[2], Richard Hoenish[3], Rachel McCarthy[4], Eric Stubbs[5], Brian Myers[5], Lyle Buss[6], Carrie Harmon[7], Richard Bostock[3], and Marc Fuchs[4]

[1]Biosecurity Research and Extension Lab, Entomology and Nematology Department, University of Florida, Gainesville, FL; [2]Cooperative Agricultural Pest Survey, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, FL; [3]Plant Pathology Department, University of California-Davis, Davis, CA; [4]Plant Pathology and Plant-Microbe Section, School of Integrative Plant Science, Cornell University, Ithaca, NY; [5]Department of Agricultural Education and Communication, University of Florida, Gainesville, FL; [6]Entomology and Nematology Department, University of Florida, Gainesville, FL; [7]Plant Pathology Department, University of Florida, Gainesville, FL

In the United States, invasive plant pests and pathogens cost approximately $20 billion in environmental damage and lost agricultural productivity per year. Florida, New York, and California have a high risk of invasive species introductions due to global agricultural imports, trade, and travel patterns. Volunteer detection networks may augment detection efforts and decrease the likelihood of the establishment of exotic species. The Collaborative and Enhanced First Detector Training Program was created to facilitate volunteer survey sample submissions following an initial educational session. First Detector workshops were planned and delivered to various audiences through multi-institutional collaborations in Florida and California during 2013 and in Florida, California,

and New York during 2014. Participants learned the following: new introduction pathways; regulatory agency procedures; identification of five to ten potentially invasive pests or pathogens; monitoring procedures; and correct sample submission. All 437 participants received standardized pre- and post-workshop surveys to measure knowledge gains. The data indicate that participants are significantly likely to monitor for invasive pests and pathogens and submit samples following an educational session. Also, participants reported an improved understanding of agencies associated with invasive species and regulation. Following the educational sessions, participants continue to provide data and related information to the training program team.

P079 Feed the Future Innovation Lab for IPM: Ecological systems-based approach

*Amer Fayad[1], afayad@vt.edu, Rangaswamy Muniappan[1], and George Norton[2]

[1]Office of International Research, Education, and Development (OIRED), Virginia Polytechnic Institute and State University, Blacksburg, VA; [2]Department of Agricultural Economics, Virginia Polytechnic Institute and State University, Blacksburg, VA

The Feed the Future Innovation Lab for Integrated Pest Management (IPM IL)—a new five-year phase of the USAID collaborative research support program managed by Virginia Tech—develops and implements effective ecological systems-based IPM programs for rice in Burma and Cambodia, vegetables in Bangladesh, Cambodia, Nepal, Kenya, and Tanzania, grains in Ethiopia, Nepal, and Tanzania, the invasive weed Parthenium in Eastern Africa, and exportable fruits in Vietnam. The IPM IL conducts modeling on the spread of the South American tomato leafminer and groundnut leafminer, and also conducts spatio-temporal assessment of biodiversity and climate change in Nepal. The program goal is to deliver and diffuse IPM research and development results on crops of high importance to USAID missions, host countries, and value chain projects in Africa and Asia and other regions when USAID missions request assistance (associate awards). The IPM IL will reduce agricultural losses due to pests, minimize damage to natural ecosystems including loss of biodiversity, and reduce contamination of food and water supplies by minimizing reliance on synthetic pesticides, and fostering the long-term sustainability of agricultural systems. The program advances IPM science and information dissemination, develops IPM technologies, builds both human and institutional capacity, improves IPM education, and links to public and private entities that disseminate IPM knowledge and products. This will result in a widespread adoption and impact of ecologically-based IPM technologies, practices, and systems leading to improved food security and livelihood of people living in poverty in the developing world.

P080 Documenting and measuring collaboration at the Regional IPM Centers

*Jean Haley[1], jahaley@illinois.edu, Keoki Hansen[2], Doris Sande[3], Yifen Liu[2], and Jean-Jacques Dubois[3]

[1]North Central IPM Center, University of Illinois, Urbana, IL; [2]Northeastern IPM Center, Cornell University, Ithaca, NY; [3]Southern IPM Center, North Carolina State University, Raleigh, NC

Researchers have used social network analysis (SNA) for decades to describe relationships among people, groups, and organizations. It is now gaining traction with companies and nonprofits as a tool for improving internal operations, for strategic planning, and for assessing change in networks over time. The Regional IPM Centers have begun to use SNA to describe their information networks and identify strengths and weaknesses within them. This poster will illustrate the process and results of a social network analysis pilot test conducted by three Regional IPM Centers. The process included developing appropriate survey instruments, collecting the data, entering the data into SNA software, and analyzing relationships using both graphical and statistical means.

P081 The IPM eAcademy: Online presentations and webinars addressing important IPM-related issues

*Danesha Seth Carley, danesha_carley@ncsu.edu, Rosemary D. Hallberg, and James R. VanKirk

Southern IPM Center, North Carolina State University, Raleigh, NC

IPM eAcademy is a new program managed by the Southern IPM Center, and presented in conjunction with the other Regional Centers. This new program will be located on the National IPM website and will feature online presentations and webinars addressing important IPM-related issues. All video content will be hosted through a YouTube Channel branded to match the National IPM website so that all IPM centers are equally represented and a social presence for IPM on the national scale is enhanced. In addition to biologically relevant topics, it will feature content on the logistics of IPM programs including program evaluation and approaches to real-time information delivery. We aspire to produce an engaging and professional quality presentations, eventually in the same league with TED talk presentations. IPM eAcademy will gather content from numerous sources. IPM Centers have committed to 12 presentations per year; however our vision is that the IPM eAcademy will grow to serve a clearinghouse function for all appropriate IPM material. Eventually we plan to seek out submissions from the IPM community including Land-grant researchers, Extension specialists, and others. SIPMC will consult with other IPM Centers, USDA-NIFA staff and other advisers to develop submission standards for quality, topicality,

length and appropriateness. We will use these standards to ensure that the IPM eAcademy honors the values of objectivity and transparency inherent in both IPM and Land-grant traditions.

P082 The Southern Region IPM Center's 2015 Friends of IPM awards

*Rosemary D. Hallberg[1] rhallberg@sripmc.org, Danesha Seth Carley[1], and Henry Y. Fadamiro[2]

[1]Southern IPM Center, North Carolina State University, Raleigh, NC; [2]Auburn University, Auburn, AL

The Southern IPM Center will present all the results of its 2015 Friends of Southern IPM Awards. The Center initiated the Friends of IPM Award Program in 2007 to recognize individuals and groups who have made extraordinary achievements in integrated pest management in the southern region. Awards are given to graduate students and professionals. The prize is public recognition of the winners' achievements: an award ceremony in front of the winners' peers and published articles about the award. The Ph.D. student winner also receives a $3,000 honorarium and the Masters student receives $2,000. Graduate student winners for 2015 include Julian Golec from the Department of Entomology and Plant Pathology at Auburn University (Masters award) and Adam Dale from the Entomology Department at NC State University (Ph.D. award). Winners of the professional awards have not yet been finalized but will be included in the poster.

P083 Integrated Pest Information Platform for Extension and Education (iPiPE): A new USDA CAP

*Scott A. Isard[1], sai10@psu.edu, and James R. VanKirk[2]

[1]Departments of Plant Pathology and Environmental Microbiology and Department of Meteorology, Pennsylvania State University, State College, PA; [2]NSF Center for IPM and Southern IPM Center, North Carolina State University, Raleigh, NC

Food security is best served by a national infrastructure of private and public professionals who routinely monitor crop health and pest incidence then translate this knowledge to a shared platform enabling rapid dissemination of mitigation measures to limit crop loss. The iPiPE CAP, funded by a 2015 USDA AFRI 5-yr $7 million grant, provides such an infrastructure with cyberage tools, information products and expert commentary for detection and management of new, foreign, or emerging target pests and endemic pests that threaten US crops. By categorizing pests, data, and users, it enables sharing observations while protecting privacy of individuals, companies, and government agencies. iPiPE Crop-Pest Programs (CPPs) will incentivize growers and consultants to submit observations on target and endemic pests by providing tools and information for timely management decisions. Coordinated by extension professionals from across the nation, programs address a variety of crops and pests and provide undergraduate students with hands-on extension and diagnostic experiences. Risk-based research will prioritize detection efforts for target pests and direct in-field scouting for endemic pests. Observations housed in a national pest observation depository will enable future research using geographically extensive, multi-year databases. iPiPE success can be measured by numbers of CPPs, participating stakeholders and trained students. While costs to establish CPPs are significant, maintenance can be sustained with minimum funding. The expansion of Crop-Pest Programs with CAP support will attract industry funding, ensuring long-term sustainability. At project completion, the iPiPE, through its expansion of Programs, will increase IPM adoption and enhance US food security.

P084 Mobile IPM: Crop management, pest identification and forecasting and monitoring in Canada

*Barbara J. Sharanowski, barb.sharanowski@gmail.com, Amber Bass, Kale McKay, and Leanne Peixoto

Department of Entomology, University of Manitoba, Winnipeg, MB, Canada

Digital tools for IPM are becoming increasingly common as smart phone technology has become accessible to most citizens and as rural areas gain access to mobile networks. We describe the latest digital tools in development for IPM of Canadian field crops. These tools include: (1) a field-based, interactive app for the identification of insects, weeds, and diseases present in key crops in Canada; (2) a forecasting and monitoring app for insects and diseases; and (3) a comprehensive crop management tool. Data links between the apps are described and their implications for research based on large-scale, long term monitoring of pest occurrence and abundance, climate data, and crop management decisions across the Canadian Prairies.

P085 Utilizing webinars to increase the adoption of IPM

*Erin M. Lizotte[1], taylo548@msu.edu, Joy N. Landis[2], and Mallory A. Fournier[2]

[1]Michigan State University Extension, Michigan State University, East Lansing, MI; [2]Integrated Pest Management Program Office, Department of Entomology, Michigan State University, East Lansing, MI

In October 2013, Michigan State University Extension launched an online, on-demand series of webinars focused on increasing grower and educator awareness of IPM (integrated pest management) resources, practices, history and implications. From December 2013-December 2014, available webinars include; Introduction to Integrated Pest Management, Integrated Pest Management Resources, Entomology 101, Plant Pathology 101,

Soil Science 101, Plant Science 101 and Insect Scouting in Fruit Crops. Webinar viewing was incentivized by partnering with the Michigan Department of Agriculture and Rural Development to provide continuing education credits for certified pesticide applicators. This approach to content delivery proved popular and allowed MSU Extension to access traditionally underserved audiences in Michigan as well as new national and international participants. The program was evaluated using an online pre- and post- survey of viewers. During the first ten months, there were 1,663 webinars viewed. An approximate 430 viewers reported an acreage impact of 1.2 million acres. Approximately 30% identified as growers, 20% landscapers, 19% recreational gardeners, 13% crop consultants, 10% agriculture educators, 8% general public, 5% pesticide distributors, 3% students, and 0.4% policy makers. Based on the preliminary evaluation of the MSU IPM Webinar Series, prerecorded and on-demand webinars offer an affordable and accessible way for stakeholders to access University resources and an efficient means for garnering a wider audience for those resources and increasing the adoption of IPM practices.

P086 Innovative programming resources to enhance IPM decisions

*Frannie L. Miller[1], fmiller@ksu.edu, Brian McCornack[1], Wendy Johnson[1], Cheryl Boyer[2], Raymond Cloyd[1], and Megan Kennelly[3]

[1]Department of Entomology, Kansas State University, Manhattan, KS; [2]Department of Horticulture, Forestry and Recreation, Kansas State University, Manhattan, KS; [3]Department of Plant Pathology, Kansas State University, Manhattan, KS

The goal of the Kansas State University IPM program is to educate constituents and stakeholders on use of safe and sustainable pest management practices through development and delivery of new, innovative science-based programming. This poster illustrates how we are developing an integrated system that broadens access to critical information in agricultural and horticultural commodities, through two goals: (1) improving data access to better inform pest management decisions in agricultural and horticultural commodities, and (2) increasing awareness and access to the IPM program and its important outputs for users. Our team is developing a web-based application that is designed for mobile use, MyFields.info, for implementing IPM by pushing management information to stakeholders based on account preferences, field locations, and varietal selections. By customizing the Extension experience for our site users, we ensure easy access to relevant resources and tools across several disciplines and a platform for multi-directional data flow (i.e. pest sampling and monitoring) to increase their awareness when crops are at risk. We have developed multidisciplinary IPM workshops for nursery producers (NurseryWorks), garden center workers (RetailWorks), and greenhouse producers. Participants indicated that they gained significant amounts of knowledge and intended to make changes to their current practices within the next 6 months. Our web presence has improved and expanded to make information more searchable and easier to find. Kansas is a large state and face-to-face meetings are logistically difficult and can be expensive. Therefore, we are developing distance training opportunities for Extension Master Gardeners, certified pesticide applicators, and other audiences.

P087 Ontario CropIPM—Interactive online IPM training modules

Margaret Appleby[1], Leslie Huffman[1], Kathryn Carter[1], Pam Fisher[1], Wendy McFadden-Smith[1], Kristy Grigg-McGuffin[1], Janice LeBoeuf[1], Elaine Roddy[1], Marion Paibomesai[1], Sean Westerveld[1], Jennifer Allen[2], and *Melanie Filotas[1], melanie.filotas@ontario.ca

[1]Ontario Ministry of Agriculture, Food and Rural Affairs, ON, Canada; [2](former OMAFRA) Agriculture and Agri-Food Canada, Burnaby, BC, Canada

Ontario CropIPM is an interactive on-line training tool created by OMAFRA specialists to provide information on pests and pest management for fruit and vegetable crops. Ontario CropIPM online was launched in 2009 and now the site features 10 crops that include apples, brassicas, cucurbits, grapes, onions, peppers, strawberries, sweet corn, tender fruit, tomatoes, ginseng and asparagus. Additional crops, including hops, tree nuts, carrots and leafy vegetables will be launched in the future. These modules provide factsheets on insects, diseases, weeds and beneficial insects as well as abiotic disorders. Key features are the detailed pictures and close-up shots and "Often Confused With" pictures to aid in pest identification. Clickable, illustrated "Identification Keys" lead the user through characteristic features to identify a pest, and "Test Your Knowledge" allows the user to assess knowledge gained from the information presented. Ontario CropIPM is targeted to growers, consultants and scouts, and is useful for both beginners (like scouts or new growers), or as a refresher for those experienced in IPM. Beginner and Advanced Levels are presented, with more detailed information on pest biology and management practices included in Advanced. An addition to some fruit modules are direct links to pesticide recommendations from OMAFRA's crop protection guides. Most modules are available online at www.ontario.ca/cropipm (French available at www.ontario.ca/licultures), or in CD format.

P088 Contemporary tools for the IPM tool box: Multi-criteria decision making and mind mapping software

*Hilary Sandler[1], hsandler@umass.edu, Keoki Hansen[2], and Katherine Ghantous[1]

[1]University of Massachusetts Cranberry Station, East Wareham, MA; [2]Northeastern IPM Center, Cornell University, Ithaca, NY

Specialists in business, health care, economics, etc., regularly use multi-criteria decision-making (MCDM) software to weigh

and analyze seemingly contradictory goals. Since IPM control options, environmental concerns, and economic pressures can be in conflict and make the decision process difficult, MCDM can be a great tool to resolve divergent IPM objectives. MCDM can prioritize strategic alternatives and identify key indicators by incorporating the decision maker's preferences and experiences (qualitative) along with economic or other quantitative data. More than 30 software packages are currently available, each with their own strengths and weaknesses. We chose to use Analytic Hierarchy Processing (AHP), along with mind mapping software, to provide MA cranberry growers with a method to identify a suitable IPM program to manage a parasitic weed pest on their farms. Dodder (*Cuscuta gronovii*) is a particularly good candidate for AHP since there is no one single tactic that provides adequate control and integration of techniques is mandatory. In addition, each farm-grower combination presents its own unique situation and weed history. Extension and industry personnel, researchers, and growers met to identify the criteria; mind maps have been constructed. Survey instruments have been developed and piloted. Growers seem willing to use AHP if the result is a workable plan of action for dodder management.

P089 Pesticide Risk Mitigation Engine (ipmprime.com): A user-friendly online tool for field-specific risk assessment and mitigation

*Patrick Shannon-Hughes[1], pshannon-hughes@ipminstitute.org, Thomas A. Green[1], Chuck Benbrook[2], Karen Benbrook[3], Susan Kegley[4], Timothy Brown[4], Pierre Mineau[5], and Daniel Skolnik[1]

[1]IPM Institute of North America, Inc, Madison, WI; [2]Organic Center, Enterprise, OR; [3]BCS Ecologic, Inc., Enterprise, OR; [4]Pesticide Research Institute, Berkeley, CA; [5]Pierre Mineau Consulting, Ottawa, ON, Canada

Pesticides are invaluable tools for food and fiber production, but pesticide use presents risks that must be carefully managed. The Pesticide Risk Mitigation Engine (ipmprime.com) is a web application designed to help mitigate the environmental impacts of pesticide use by improving the selection of pest management options and conservation practices. Using a novel approach to risk calculation based on site-specific conditions, pesticide properties and empirical field impact data (where available), ipmprime.com estimates risk to workers, consumers, birds, small mammals, earthworms, pollinators and aquatic ecosystems. Ipmprime.com weighs impacts of application methods and the quantity and frequency of application, and uses NRCS soils data and other site-specific information, such as conservation practices and the presence of sensitive areas, to improve the accuracy of risk calculations and help the user make informed decisions about pesticide use and risk mitigation. Using state-of-the-art pesticide fate and transfer modeling and a suite of environmental risk indicators, ipmprime.com can be useful in supporting IPM programs by helping to minimizing the environmental risks when chemical suppression is necessary, it is already part of Whole Foods Market's Produce Rating System. This poster will describe the science behind ipmprime.com risk modeling, features of the web application and an example of how ipmprime.com works.

P090 A proposed Center for Ecology, Evolution and Management of Pesticide Resistance

*Blair Siegfried[1], bsiegfried1@unl.edu, Todd Gaines[2], and Philip Westra[2]

[1]University of Nebraska, Lincoln, NE; [2]Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO

A proposal to the NSF Industry/University Cooperative Research Center (I/UCRC) program is being developed to fund The Center for Ecology, Evolution and Management of Pesticide Resistance (CEEMPR). The vision for the Center is to transform the field of pesticide resistance management by: 1) systematically, objectively, and transparently identifying, prioritizing, and funding coordinated research on the factors contributing to resistance evolution and 2) implementing strategies and developing solutions that promote the long-term sustainability of environmentally sound pest management approaches. The proposed I/UCRC will be established jointly by the University of Nebraska-Lincoln and Colorado State University and represents a unique opportunity for industry and academia to partner in coordinated research to identify the factors contributing to resistance evolution among important insect, weed, and plant pathogens.

P091 Factors affecting pistachio growers' adoption of IPM practices in Kerman Province, Iran

*Mohammad Mohammadrezaei[1], Mohammadrezaei.mohammad@yahoo.com, and Dariush Hayati[2]

[1]Department of Agricultural Extension and Education, Collage of Agriculture, Tarbiat Modares University, Tehran, Iran; [2]Department of Agricultural Extension and Education, Collage of Agriculture, Shiraz University, Shiraz, Iran

Pistachio is one of the main agricultural crops in Iran. Pistachio export and production has been reduced by drought, pest damage and chemical pesticide residuals, in Iran. The history of IPM technology is more than 20 years old in Iran but IPM adoption by farmers is very low. Factors affecting pistachio growers' adoption of IPM practices in Kerman Province were the main objective of this study. Survey research was the research method. Two stage cluster sampling was used as the sampling method. Therefore, 306 pistachio growers were selected as a sample group. A questionnaire was used as a data collection instrument. Its face validity was confirmed by a panel of Shiraz University professors and its reliability was

examined by conducting a pilot study among pistachio growers in Neyriz county which is located in Fars Province. Cronbach's Alpha coefficients were obtained between 0.66 to 0.89. Findings revealed there was a negative correlation between some independent variables (pistachio grower's age; farming experience; chemical pesticide costs; IPM operational challenges) and a positive correlation between some independent variables (benefiting of agricultural extension services; pistachio grower's net income; their participation; their welfare and existence motivation; their IPM knowledge; their attitude toward IPM environmental impacts) and pistachio growers' IPM adoption. Path analysis results revealed pistachio grower's IPM knowledge and their attitude toward IPM environmental impacts have considerable affect on their IPM adoption. Also, their benefit of agricultural extension services has a positive impact on their IPM knowledge and attitude and therefore, on their IPM adoption.

P092 On not reinventing the wheel: The Northern Plains IPM Working Group

*Kelley J. Tilmon[1], kelley.tilmon@sdstate.edu, and Buyung A. R. Hadi[2]

[1]Department of Plant Science, South Dakota State University, Brookings, SD; [2]Crop and Environmental Sciences Division, International Rice Research Institute, MetroManila, Philippines

The Northern Plains IPM Working Group, a project of the North Central IPM Center, is a collaborative body of entomologists, plant pathologists, and IT specialists. The goal of this working group is to combine and repurpose extension material already developed by its members in order to produce regional extension products which are useful across state borders. This creates an economy of effort which is important in light of shrinking extension staffing in most state extension services. Two such products are the Northern Plains IPM Guide and the award-winning Northern Plains IPM mobile app. This poster outlines the collaborative process whereby these group projects are created.

P093 Advancing IPM for Midwest apple production using the Pesticide Risk Mitigation Engine (ipmPRiME.com)

*Patrick Shannon-Hughes, pshannon-hughes@ipminstitute.org, Peter Werts, and Thomas A. Green

IPM Institute of North America, Inc, Madison, WI

Apple production requires highly managed use of pesticides to produce commercial quantities and quality fruit. This presents risks from pesticides that must be carefully addressed. A network of apple producers in the upper Midwest used the Pesticide Risk Mitigation Engine (ipmPRiME.com) between 2011 and 2014 to track changes in pesticide risk, as they implemented advanced IPM. IpmPRiME.com is a web application designed to monitor and mitigate the environmental impacts of pesticide use by improving selection of pest management options and conservation practices. Using a novel approach to risk calculation based on site-specific conditions, pesticide properties and empirical field impact data (where available), ipmPRiME.com estimates risk to workers, consumers, birds, small mammals, earthworms, pollinators and aquatic ecosystems. IpmPRiME.com weighs impacts of application methods and the quantity and frequency of application, and uses NRCS soils data and other site-specific information, such as conservation practices and the presence of sensitive areas, to improve the accuracy of risk calculations and help the user make informed decisions about pesticide use and risk mitigation. Using pesticide fate and transfer modeling and a suite of environmental risk indicators, ipmPRiME.com can be useful in supporting IPM programs by helping to minimizing the environmental risks when chemical suppression is necessary. This poster will describe the science behind ipmPRiME.com risk modeling, features of the web application and highlight how ipmPRiME.com is being used with a network of Midwest apple producers to track changes in pesticide risk through the adoption of advanced IPM strategies.

P094 Building IPM capacity in Missouri through train-the-trainer workshops and effective partnerships

Jaime C. Piñero, pineroj@lincolnu.edu

Lincoln University Cooperative Research and Extension, Jefferson City, MO

Since its inception in 2010, the Lincoln University (LU) IPM Program has been developing (through research) and promoting (through Extension) effective and affordable IPM strategies to combat pests affecting vegetable and small fruit production in Missouri. From 2011 to 2013 the LU IPM program partnered with the Missouri Sustainable Agriculture Research and Education (SARE) program and implemented four train-the-trainer workshops on vegetable IPM (2011), small fruit IPM (2012), sustainable management of weeds and soil-borne diseases (2013) and the invasive Spotted Wing Drosophila (2013). Overall, subject matter experts from nine US states provided training to 138 Extension educators from Univ. of Missouri Extension, LU Cooperative Extension, USDA Natural Resources and Conservation Service (NRCS), Missouri Department of Agriculture, Missouri Department of Conservation, University of Illinois Extension, and University of Nebraska Extension. Educators indicated that they increased significantly their IPM knowledge leading to improved abilities to assist farmers. The implementation of these 2-day workshops also resulted in important mid-term outcomes. For example, results from 9-month post-workshop surveys indicated that: (1) 2,453 farmers were assisted by 83 trainees using IPM information received at the workshops, (2) 26.5% of the respondents wrote articles for newsletters and/or newspaper columns using IPM information (131 total outputs), and (3) 89.3% of the respondents visited 595 farms and used IPM information. Overall, the implementation of this type of Extension IPM

activities has proven successful, and the outcomes highlight the efforts that the LU IPM program is taking to train Extension educators within and outside Missouri in necessary IPM skills.

P095 Using interactive activities to educate and prepare workers for the Oregon pesticide applicator exam

*Gilbert Uribe, gilbert.uribe@oregonstate.edu, and Luisa Santamaria

North Willamette Research and Extension Center–Oregon State University, Aurora, OR

There is a very high demand and low supply of licensed pesticide applicators in the Oregon agriculture industry. During the past three years, the pass rate for the Spanish language version of the Oregon Private Pesticide Applicator License Exam has been under 40%. Every Thursday of October at the North Willamette Research and Extension Center, the OktoberPest series offers workshops of different IPM topics of interest to all the agricultural commodities in Oregon. Last year, three workshops were offered in Spanish in collaboration with the Oregon Department of Agriculture to support agricultural workers interested in obtaining pesticide applicator certification. The exam is offered in either a paper or computer-based format. However, a large portion of the target audience lacks familiarity with many basic computer functions. A practice, online exam was offered to all participants during each of the workshops to allow them to become more comfortable with the format. Additionally, after a brief slideshow presentation, the participants worked in groups to answer test-like questions using label information. As the series progressed, it was clear that participants who had attended multiple workshops became more comfortable using computers. During the second workshop, 85% of responses to a survey question expressed a desire to take the computer-based pesticide exam. That number rose to 89% after the third workshop. The overall goal is not only to get workers to pass the exam, but to become more knowledgeable about pesticides and pest management in order to minimize hazards associated with pesticide application and use.

P096 Sysco Sustainable Agriculture/IPM program

*Patrick Shannon-Hughes[1], pshannon-hughes@ipminstitute.org, Thomas A. Green[1], and Georgiann Miller[2]

[1]IPM Institute of North America Inc., Madison, WI; [2]Sysco, Houston, TX

Sysco's Sustainable Ag/IPM program was initiated in 2004 to protect ecologically sensitive areas; improve air, water and soil quality; reduce, reuse and recycle resources; conserve energy and encourage the responsible use of agricultural inputs. Performance of Sysco suppliers and growers participating in this program is measured based on a written Sustainable Ag/IPM program specific to processing facilities and field production, an on-site, third-party evaluation and an annual supplier self-report of environmental indicators, including statistics relating to pesticide and nutrient applications. Since reporting of environmental indicators began in 2005, the program has experienced a general increase in the number of suppliers and amount of acres enrolled as well as a significant reduction in the total amount of pesticide and nutrients applied. The program began with 74 original suppliers, increasing to 78 suppliers in 2013. In 2005, 375,000 acres were under the IPM program; over the years, the number of acres enrolled has risen to 898,175,000 acres, as indicated in the 2013 annual report. As the amount of acreage has increased, suppliers have reported substantial avoidance of amounts of pesticides applied due to the implementation of IPM techniques, including scouting, weather monitoring, crop rotation and more. Sysco continues to track supplier pesticide use in pounds of active ingredient per acre and by acute toxicity to mammals, indicated by the signal word (Danger, Warning or Caution) on the product label. In 2014 Sysco introduced standards on pollinator protection to encourage beneficials in their commodity production.

P097 NYS dairy cattle IPM: Research and outreach addressing dairy industry needs

*J. Keith Waldron[1], jkw5@cornell.edu, Kenneth L. Wise[1], and Donald A. Rutz[2]

[1]New York State Integrated Pest Management Program, Cornell University, NYSAES, Geneva, NY; [2]Department of Entomology, Cornell University, Ithaca, NY

Dairy Integrated Pest Management (IPM) is an important component of Cornell University's New York State Livestock and Field Crop IPM Program extension outreach. This effort draws upon the work done at the Cornell University Veterinary Entomology Program and other land grant institutions for research-based dairy cattle IPM information. The focus of the dairy IPM effort is to enhance producer, agricultural industry and extension personnel knowledge and skills regarding integrated approaches to managing biting and nuisance fly issues affecting dairy cattle in barns and on pasture. In addition to servicing the pest management needs of the state's conventional and organic dairy producers through educational meetings on and off the farm, the program has enhanced dairy fly management information delivery electronically via a teleconference, webinars, an on-line train-the-trainer dairy barn fly IPM module and factsheets addressing dairy cattle pests. An organic dairy IPM guide has recently been published and is also available on-line. These resources contain IPM material and approaches appropriate for use in the northeast US and other dairy production regions with similar fly pest issues. A "moodle-based" training module is in development for clientele to learn dairy cattle IPM and earn NYS pesticide recertification credits. An update on recent NYS Livestock IPM activities, resources and program status will be presented. Dairy cattle

IPM information can be found at: www.nysipm.cornell.edu/livestock/.

P098 Soil treatment with destabilized compost and solarization: An alternative to fumigants

*James J. Stapleton[1], jjstapleton@ucanr.edu, Ruth M. Dahlquist[2], Christopher W. Simmonsi[3], Megan N. Marshall[4], and Jean S. VanderGheynst[5]

[1]Statewide IPM Program, University of California (UC) Kearney Agricultural Center, Parlier, CA; [2]UC Cooperative Extension, Fresno, CA; [3]Department of Food Science & Technology, UC Davis, Davis, CA; [4]Department of Agricultural & Biological Engineering, Pennsylvania State University, University Park, PA; [5]Department of Biological & Agricultural Engineering, UC Davis, Davis, CA

Knowledge-based application of organic materials (e.g., anaerobic soil disinfestation/biological soil disinfestation) and soil solarization can be useful as pre-plant treatments to eliminate soil pests, without using synthetic chemical fumigants. With the goal of making both approaches more effective, predictable and flexible, we tested mortality of *Brassica nigra* (black mustard) seeds in solarized field soil amended with mature green waste compost, and destabilized with wheat bran, as compared to non-amended field soil. The soils were treated in the field at Parlier, CA for 22 days or 15 days in two summer experiments. Mortality of seeds buried in compost-amended soil was significantly higher than in non-amended soil in both trials. Additional laboratory and field studies showed that amended and destabilized soil was initially phytotoxic to lettuce seedlings. However, phytotoxicity was eliminated by subsequent solarization treatment. Amended soil resulted in maximum temperatures 2-4°C higher than in soil alone, and ~85% of total organic carbon in amended soil was exhausted within 22 days of heating by solarization. Bacterial community structure in solarized soils were measured by 16s rDNA sequencing. Community structure changed based on soil amendment and solarization. Also, bacterial communities varied with soil depth, indicating possible enrichment of thermophiles and other niche-specific taxa. For further information see: Simmons et al, Applied Soil Ecology 73:97-104 (2014); Marshall et al, Transactions of the American Society of Agricultural & Biological Engineers 56:117-133 (2013); and Simmons et al, Waste Management 33:1090-1096 (2013); website http://ucanr.edu/sites/Solarization/.

P099 Food-Safe compounds to protect Southern dry cured hams from the ham mite, *Tyrophagus putrescentiae*

*Salehe Abbar[1], abbar@k-state.edu, M. Wes Schilling[2], and Thomas W. Phillips[1]

[1]Department of Entomology, Kansas State University, Manhattan, KS; [2]Department of Food Science, Nutrition and Health Promotion, Mississippi State University, Mississippi State, MS

The ham mite, *Tyrophagus putrescentiae*, is a common pest in southern dry cured hams, aged cheeses and semi-moist pet foods. Southern dry cured hams often become infested with ham mites during the aging process. The most effective tool to eradicate the ham mite is the fumigant methyl bromide. Of the alternatives tested, none can equal methyl bromide in effectiveness and practicality. There is an urgent need to find alternatives since methyl bromide will be banned in the US as an ozone depleting compound. In this work the efficacy of coating hams with various safe food additives was studied. We conducted laboratory assays with small cubes of ham that were dipped into or coated with more than twenty compounds individually. Population growth of ham mites was evaluated after two weeks on treated cubes. Our results show that effectiveness of mite population suppression increased with higher concentrations of these food additives to cubes of ham. Treated ham cubes with propylene glycol, lard, ethoxyquin and butylated hydroxytoluene (BHT) reduced the population growth significantly at the highest doses and merit further study as potential ham mite control or pest management agents. Together with other IPM techniques, food-safe coatings could aid in prevention of pest mite increases in ham facilities.

P100 Systemic deterrence of aphid probing by natural and altered terpenoids may hinder virus transmission

*Beata Gabryś[1], b.gabrys@wnb.uz.zgora.pl, Katarzyna Dancewicz[1], Bożena Kordan[2], Aleksandra Grudniewska[3], Anna Gliszczyńska[3], Antoni Szumny[3], and Czesław Wawrzeńczyk[3]

[1]Department of Botany and Ecology, University of Zielona Góra, Poland; [2]Department of Phytopathology and Entomology, University of Warmia and Mazury, Olsztyn, Poland; [3]Department of Chemistry, University of Environmental and Life Sciences, Wrocław, Poland

Aphids transmit nearly 30% of all known plant virus species and 50% of insect-borne viruses. Plant diseases caused by these viruses may reduce yields by up to 80%. Aphids acquire and inoculate viruses during various stages of plant penetration with sucking-piercing mouthparts: during brief intracellular probes in epidermis and parenchyma (mesophyll in leaves) that precede feeding in phloem vessels, aphids may transmit non-persistent and semi-persistent viruses and when aphid stylets reach sieve elements, persistent viruses may be transmitted. Reducing or eliminating penetration of plant tissues by aphids could reduce infection by pathogens. Considering the selectivity and behavior-modifying potential of plant-derived chemicals, especially the terpenoids, several attempts have been

made to apply these compounds as alternatives to conventional neurotoxic pesticides. Following the biopesticide-related approach to aphid control and reduction of virus transmission, we present results of our multi-year research on aphid probing behavior-modifying activity of several natural and chemically-modified terpenoids. Research included innovative application of electrical penetration graph (EPG) technique for monitoring feeding deterrent activity against aphids. Aphid probing was impeded at pre-ingestive (pre-phloem) and/or ingestive (phloem) phases, which revealed that compounds passed through the plant surface and were distributed systemically within plant tissues. Chemical modification of naturally occurring terpenoids, e.g., incorporation of functional groups, epoxidation, or lactonization, produced significant changes in their activity profiles. Modified terpenoids varied in potency and persistence of behavioural effects on aphid probing, and certain modifications caused a shift from attractant to deterrent properties, or vice versa.

P101 Exploring insect-associated fungal flora in central mixed agriculture zone in Pakistan

*Waheed Anwar, waheedanwar.iags@pu.edu.pk, Salik Nawaz Khan, Ahmad Ali Shahid, Usman Hameed, Muhammad Javed Iqbal, and Muhammad Saleem Haider

Institute of Agricultural Sciences, University of the Punjab, Lahore, Pakistan

Agroecological distribution of insect-associated fungi of the central mixed agriculture zone of Punjab Province in Pakistan was determined. Insect-associated fungi were classified as entomopathogens, opportunistic pathogens or secondary colonizers isolated from the *Gallaria mellonella* used as a bait insect exposed to the soil samples. Soil samples were collected from three districts belonging to different localities of Punjab's central mixed zone. The frequencies of insect-associated fungal species were different in all districts. Total frequency of occurrence of entomopathogens was highest (13.16%) in district Okara among all types of observed fungal species, compared to 7.15% in district Kasur and 6.25% in district Lahore. Frequency of occurrence of opportunistic fungi was the highest in district Lahore (53.13%) among all types of observed fungal species compared to 51.89% in district Kasur and 39.47% in district Okara. Frequency of occurrence of secondary colonizer fungi was the highest in district Okara (47.37%) among all types of observed fungal species compared to 41.08% in district Kasur and 40.63% in district Lahore. Recent research advances have revealed aspects of the ecology of the fungi that are relevant for conservation biological control.

P102 20+ years of successful area-wide control for codling moth using sterile insect technique

*Cara Nelson, cnelson@oksir.org, and Melissa R. Tesche

Okanagan-Kootenay Sterile Insect Release Program, Kelowna, BC, Canada

The Okanagan-Kootenay Sterile Insect Release (OKSIR) Program is a very successful area-wide IPM program for codling moth (*Cydia pomonella*) control in apple and pear orchards of south-central British Columbia, Canada. First established in 1991, OKSIR delivers an integrated program, including monitoring, enforcement, education, and control through sterile insect technique (SIT), across 3,416 hectares. Over the last 20+ years, OKSIR's IPM program has reduced the wild moth population by 94%, while reducing pesticides use for *C. pomonella* by 96%—minimizing risk to human health and the environment. The truly area-wide nature of the program ensures potential residential and feral source populations are controlled, while allowing for a more effective IPM program at a fraction of the cost. Where the program has been operating longest, 98% of orchards in the program meet the economic target of ≤ 0.2% fruit damage from codling moth, and a 2014 cost-benefit analysis of the program revealed that for every $1 in cost there was $2.50 in benefit (both for the producers and for society). The Program is governed by a Board of Directors with elected representatives from the four regional governments in the service area and three grower representatives nominated by industry. Funding is split between local taxpayers (60%) and commercial pome fruit growers (40%). The program's state-of-the-art rearing facility has an annual production capacity of 780M sterile codling moths, and the program is a major seasonal employer for parts of the region.

P103 Contribution of GM crops to IPM and agroecology

*Heikki M.T. Hokkanen[1], heikki.hokkanen@helsinki.fi, Ingeborg Menzler-Hokkanen[1], and Alexander Wezel[2]

[1]Department of Agricultural Sciences, University of Helsinki, Helsinki, Finland; [2]Department of Agroecology and the Environment, ISARA-Lyon, Lyon, France

A range of currently available and close-to-the-market GM crops incorporating crop protection traits were examined for their potential contribution to integrated pest management and agroecology in different cropping contexts. Most GM crops and their new traits have the potential to significantly improve crop production especially under heavy pest, disease and weed pressure. In particular insecticidal and virus-resistant crops can help to keep pests and diseases in check, to lower the chemical pesticide load in the environment, and support complementary integrated pest management tactics such

as increased reliance on natural control. The agroecological benefits of herbicide-tolerant crops, however, remains more controversial, as no clear decrease of pesticide inputs can be demonstrated, and intensified simplification of the ecosystem hampers the beneficial action of ecosystem services such as biocontrol and pollination. In reality, also the theoretical benefits of pest and disease resistant GM crops seldom seem to be realized in a sustainable way, because GM crops are seen by the growers as a stand-alone technology for pest and disease control, without any real attempt to integrate it as a component in integrated pest management. This leads to short-term, unsustainable agroecological benefits, and eventual loss of the benefits as has been observed already in parts of the US by the return of the growers to conventional maize varieties. Thus, the "reality gap" appears to erode the contribution of GM crops to IPM and agroecological sustainability, and calls in question the wastage of rare opportunities to increase the sustainability of our food production via short-sighted production strategies.

P104 The role of soil moisture in biofumigation of potato cyst nematodes (*Globodera* spp.)

*William D. J. Watts, wwatts@harper-adams.ac.uk, Ivan G. Grove, Paul Hand, and Matthew A. Back

Harper Adams University, Nematology Group, Shropshire, UK

Potato cyst nematodes (PCN) *Globodera pallida* (Stone) and *G. rostochiensis* (Woll.) are the most problematic soil-borne parasites of potato (*Solanum tuberosum* L.) in the UK. Management is often reliant on nematicides, however, due to new legislation the probability of nematicides being withdrawn from industry is increasing. Biofumigation represents a potential alternative. It involves growing high glucosinolate (GSL) brassica green manure crops for maceration and incorporation into soil. Upon cell disruption the GSL's are hydrolyzed to isothiocyanates (ITC) which are known to be nematicidal. However, the role of soil moisture in effective biofumigation of PCN is still unknown. A preliminary glasshouse experiment at Harper Adams University (UK) has investigated this area, examining the mortality of PCN encysted eggs under four soil moisture treatments (25, 50, 75, and 100% of field capacity (FC)) with and without biofumigation (*Brassica juncea* cv. ISCI 99). Biofumigation reduced PCN viability by between 36-44% compared to untreated controls, however, no differences in efficacy between biofumigant treatments was recorded. Regression analysis was also performed and increasing biomass quantity at 25, 50 and 75%FC was found to reduce biofumigant efficacy, whilst at 100%FC the inverse was recorded. It is possible that at 25-75%FC ITC was not effectively retained but released to the atmosphere, whilst at 100%FC increased soil moisture facilitated ITC retention in soil solution. Increased biomass inclusion could have physically opened soil structure which explains the reduced efficacy at 25, 50 and 75%FC where soil moisture content was lower. Repeat work is needed to investigate these hypotheses.

P105 Biopesticides: A focus at Agriculture and Agri-Food Canada's Pest Management Centre

*Cezarina Kora, Cezarina.Kora@agr.gc.ca, Jinxiu X. Zhang, Tobias Laengle, and Leslie Cass

Pesticide Risk Reduction Program, Pest Management Centre, Agriculture and Agri-Food Canada, Ottawa, ON, Canada

The Pest Management Centre (PMC) of Agriculture and Agri-Food Canada was established in 2003 to improve growers' access to newer, safer pest control products and management approaches that reduce reliance on pesticides. The Pesticide Risk Reduction Program of PMC focuses on delivering reduced risk pest management solutions including biopesticides, classical biological controls and integrated approaches for agricultural crops. Biopesticides are considered an important IPM tool as these contribute to reducing the use of chemical pesticides, allow better rotation opportunities and minimize the risk for development of resistance to pesticide active ingredients. Therefore, enabling the use of biopesticides as part of IPM systems is a key activity of the Program in achieving its goal of reduced risks to human health and the environment from pesticide use in agriculture. The Program consults nationally with stakeholders at the Biopesticide Priority Setting Workshop held annually in March to identify priority biopesticides for regulatory support and project work. Dozens of new biopesticide products, representing hundreds of new uses have been made available in Canada over the past 10 years through the support of the Program.

P106 IPM for leek moth—Successful partnerships achieving the research to technology transfer continuum

*Cezarina Kora[1], Cezarina.Kora@agr.gc.ca, Kathryn Makela[1], and Peter Mason[2]

[1]Pesticide Risk Reduction Program, Pest Management Centre, Agriculture and Agri-Food Canada, Ottawa, ON, Canada; [2]Eastern Cereal and Oilseed Research Centre, Agriculture and Agri-Food Canada, Ottawa, ON, Canada

Leek moth, *Acrolepiopsis assectella*, is a serious pest of *allium* species in Eastern Ontario and Western Quebec regions of Canada, and is rapidly expanding its distribution range. In partnership with provincial specialists, Canadian universities, federal scientists, and international research organizations the Pest Management Centre's Pesticide Risk Reduction Program funded three projects over the past ten years to generate knowledge on pest biology, develop pest control tools and practices, and communicate results to growers. As a result, growers now have access to multiple alternative approaches

which enable integrated leek moth management, including reduced risk products (spinosad and *Bacillus thuringiensis* subspecies *kurstaki*), information on the use of protective row covers and establishment of overwintering populations of the parasitoid *Diadromus pulchellus*, a biological control agent specific to *A. assectella*. Through a farmer participatory approach growers were engaged at various stages of the work, increasing their knowledge of the pest and the reduced risk approaches that resulted from this research. The full spectrum of leek moth IPM elements available to Canadian growers will be presented.

P107 A web-based cover crop decision tool for integrated crop management in Eastern Canada

*Cezarina Kora[1], Cezarina.Kora@agr.gc.ca, and Laura Van Eerd[2]

[1]Pesticide Risk Reduction Program, Pest Management Centre, Agriculture and Agri-Food Canada, Ottawa, ON, Canada; [2]University of Guelph, Ridgetown, ON, Canada

Cover crops can be an important tool in sustainable agriculture, with many of them recognized to provide benefits in suppression of nematodes, weeds and other pests, as well as improving soil tilth and optimizing nutrient cycling. There is currently a growing interest in using cover crops as part of integrated management strategies to reduce pesticide input, in particular herbicides, in Canada's eastern provinces. A large body of information regarding the use of cover crops has been generated over the years and many potentially beneficial attributes have been documented for a number of plant species. However, from a grower's perspective, any given cover crop must be carefully selected and properly managed to achieve its full potential, because performance is highly dependent upon local conditions such as soil type, pest, climate and cropping systems. With support from Agriculture and Agri-Food Canada's Pesticide Risk Reduction Program and in collaboration with University researchers and provincial experts, a web-based cover crop decision making tool was developed and made available to assist growers in Eastern Canada gain access to relevant information and make scientifically sound cover crop choices. The scope of the tool and how it can be used by growers to make customized decisions in selecting suitable cover crops to match their planting conditions and desired beneficial outcomes is presented.

P108 Advances in integrated management of fusarium head blight through Canada's Pest Management Centre

*Cezarina Kora[1], Cezarina.Kora@agr.gc.ca, and Allen Xue[2]

[1]Pesticide Risk Reduction Program, Pest Management Centre, Agriculture and Agri-Food Canada, Ottawa, ON, Canada; [2]Eastern Cereal and Oilseed Research Centre, Agriculture and Agri-Food Canada, Ottawa, ON, Canada

Fusarium head blight (FHB), caused by *Fusarium* spp. is the most destructive and economically important disease affecting wheat production across Canada. The disease reduces yield and grade of wheat grains due to mycotoxin contamination of kernels. Since there have been no fully resistant wheat varieties available commercially, FHB management has mainly relied on regular applications of chemical fungicides. The Pesticide Risk Reduction Program of Agriculture and Agri-Food Canada's Pest Management Centre set out to develop a reduced risk strategy for sustainable FHB management in 2006. Under this strategy, the Program has funded ten research and development projects, with some of them focusing on improved accuracy and validation of disease forecasting models for better disease risk assessment and timing of fungicide applications. Other projects focused on assessing cultural control methods and developing a biological control product. As one outcome of this work, a new strain of the beneficial fungus *Clonostachys roseae* native to Canada (ACM941) is being developed as a biopesticide option for Canadian cereal growers. Progress achieved with the FHB strategy work and the outcomes resulting from projects supported by the Program will be presented.

P109 Management of the cabbage maggot in *brassica* vegetables using polyethylene insect netting

*Peggy Dixon[1], Peggy.Dixon@agr.gc.ca, Scott Anderson[2], Josée Owen[3], and Viliam Zvalo[4]

[1]Atlantic Cool Climate Crop Research Centre, Agriculture and Agri-Food Canada (AAFC), St. John's, NL, Canada; [2]Crops & Livestock Research Centre, AAFC, Charlottetown, PE, Canada; [3]Potato Research Centre, AAFC, Fredericton, NB, Canada; [4]Vineland Research and Innovation Centre, Vineland, ON, Canada

Cabbage maggot (CM) (*Delia radicum* (Diptera: Anthomyiidae)) is a key pest of *brassica* vegetables in Canada. Maggot feeding can kill or stunt young plants, and reduce marketability of mature root crops. Chlorpyrifos is the only insecticide registered in Canada for CM but insect resistance is increasing: 75% of populations tested in British Columbia in 2013 were resistant to chlorpyrifos. Few new insecticides against CM are being developed, leaving few options for growers. Long-lasting polyethylene insect netting is used successfully against CM and other pests on thousands of acres of *brassica* vegetables in Europe. Agriculture and Agri-Food Canada scientists evaluated this netting against CM in rutabaga in eastern Canada during 2010-12. The netting successfully protected the crop against CM but due to the season-long placement of the netting required for rutabaga, weed pressure sometimes reduced marketable yields. A second project (2014-16) is investigating use of the netting in leafy brassicas, which need only early-season

protection against CM; netting is removed after a few weeks, and weeds controlled as usual. Three different gauges of netting are being tested, and in addition to CM damage, abiotic conditions under and outside the netting, and effects on other pests, are being measured. The project also seeks to develop methods to increase grower adoption/uptake of the insect netting technology, including: use of social media, field demonstrations, platforms such as regional commodity/extension networks and public data sites, videotaping the use of specialized machinery to install and remove the netting, and classical approaches like factsheets.

PI10 Hybrid of *Rumex patientia* × *Rumex tianschanicus* (*Rumex* OK-2)—A new invasive weed in Central Europe

*Lenka Pavlů[1], lpavlu@vurv.cz, Renata Hujerová[1], and Vilém Pavlů[1,2]

[1]Department of Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences, Prague, Czech Republic; [2]Department of Weeds and Vegetation of Agroecosystems, Crop Research Institute, Prague, Czech Republic

Most broad-leaved *Rumex* species are troublesome weeds. *Rumex* OK-2 is a hybrid dock of *R. patientia* L. and *R. tianschanicus* A. Los. It was bred in Ukraine by Prof. Uteush for forage and energy use. This taxon has recently been introduced into other European Countries. In the Czech Republic, *Rumex* OK-2 has been planted since 2001 mostly like an energetic crop (biofuel). It can potentially become a new invasive weed species, because the escape of *Rumex* OK-2 plants from cultivation into surrounding grassland has been recorded. Therefore we conducted field studies for recording the dynamic of its expansion. Consequently we established several greenhouse experiments to obtain knowledge about its ecological characteristics and then compared them with other broad-leaved *Rumex* species. The field survey showed the expansive spreading of the *Rumex* OK-2 from former fields especially along roadside ditches. In the pot experiment it was revealed that aboveground and belowground biomass responses to cutting were very similar to *Rumex crispus*. Further the growth dynamics and allocation of belowground biomass of *Rumex* OK-2 was more similar to *R. crispus* than to *R. obtusifolius*. Finally there was recorded crossbreeding *Rumex* OK-2 with the other broad-leaved *Rumex* species.

PI11 Integrated Pest Management (IPM) in grain legumes in Asia

*G.V. Ranga Rao, G.Rangarao@cgiar.org, and H.C. Sharma

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, TS, India

Insect pests are a major constraint in legume production and storage. Legume pests are often sporadic, and at times cause complete destruction of crops. There has been a shift in pest spectrum in Asia over the past five decades, and polyphagous pests such as red hairy caterpillar, *Amsacta albistriga*, white grub, *Holotrichea serrata*, and leaf miner, *Aproaerema modicella* are no longer a threat in groundnut production; while beet armyworm, *Spodoptera exigua*, legume borer, *Maruca vitrata*, mealy bug, *Phenacoccus solenopsis*, thrips as vectors of viral diseases in groundnut, and termites have become a serious constraint in production of grain legumes. The importance of cotton boll worm/ legume pod borer, *Helicoverpa armigera* and tobacco caterpillar, *Spodoptera litura* has remained unchanged. In general, virus vectors (thrips, aphids and mites) and the pulse bruchid, *Callasobruchus chinensis* and the groundnut bruchid, *Caryedon serratus* have become more serious. Research at ICRISAT in cooperation with NARS and NGOs in a participatory approach has emphasised utilization of pest-resistant cultivars, adoption of potential agronomic practices, augmenting natural enemies, and integrating various options to enhance the productivity of grain legumes along with environmental and operational safety. Using this approach, several indigenous plant protection practices were brought to the forefront. This poster updates the status of IPM in Asia with special reference to legume crops.

PI12 Use of *Trichoderma asperellum* and *Glomus intraradices* as biocontrol agents against okra seedlings infected with plant pathogens

*A.O. Salami, sola1salami@yahoo.com, and O.O. Idumu

Department of Crop Production and Protection, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria

Biological control agents are known to reduce the effect of plant pathogens and the environmental hazards caused by the persistent use of synthetic chemicals. This study evaluates the effect of bio-control agents against *Abelmoschus esculentus*, okra seedlings infected with *Erwinia carotovora* and *Pythium aphanidermatum*. Different combinations of these micro-organisms were observed on the growth performance of okra seedlings. This was done using plant growth parameters such as stem girth, number of leaves, stem height and leaf area. The results show that the bio-control agents reduced the negative effect of the pathogen on the young seedlings while *G. intraradices* enhanced the development of these plant parameters. The organisms had less synergistic effect on each other due to their competitiveness and high requirements for metabolic plant products but produced more antagonistic effect on the pathogenic micro-organisms. Therefore it was concluded that *G. intraradices* and *T. asperellum* could be effectively used as bio-control agents to reduce the effect of *E. carotovora* and *P. aphanidermatum* on young okra seedlings. *G. intraradices* and *T. asperellum* suppressed the penetration, colonization and establishment of the pathogens used in the root of young okra seedlings. The control of the pathogen depends on the stages

of development of plant root system, the population, selection and combination of control measures. Control of the pathogenic micro-organism using only one antagonistic micro-organism was more effective, because it limits the number of organisms utilizing the products of plant metabolism which has a negative effect on the growth parameters of young plant.

P113 NRCS & IPM Working Group: Grower incentives for IPM

*Thomas A. Green, ipmworks@ipminstitute.org, and Chloe L. Nelson

IPM Institute of North America, Inc. Madison, WI

First created in the 1996 Farm Bill, the USDA Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) is a key opportunity to increase IPM adoption in agriculture. EQIP is a voluntary conservation program offering technical and financial assistance to private landowners, including help implementing and maintaining IPM. Since 2006, the NRCS and IPM Working Group has encouraged farmer adoption of IPM practices through participation in NRCS conservation programs and was successful in increasing participation in NRCS programs for IPM in the North Central region between 2008 and 2011. The Working Group is comprised of NRCS and IPM professionals and provides a forum for communication; identification, prioritization and reporting of regional needs, outcomes and impacts; and sharing IPM Center information with funding from the USDA North Central IPM Center. This past year, the Working Group analyzed recent trends in participation for EQIP and found that nationally, participation has dramatically decreased since 2008. We've identified probable causes including frequent changes in NRCS programs; poor communication of changes; a lack of outreach to farmers, crop advisors and other key influencers; and low awareness of the benefits of IPM and its potential to address resource concerns. To address these concerns, the Working Group is increasing outreach to growers and crop advisors to increase awareness of and participation in EQIP for IPM; identifying and filling in gaps in NRCS's web-based training platform with existing and newly developed training resources; and working directly with NRCS leadership to improve communications about IPM throughout NRCS.

P114 Environmental drivers of trait changes in *Photorhabdus* spp.

*Dana Blackburn, blackbud@byu.edu, Burke Crawford, and Byron Adams

Department of Biology, Brigham Young University, Provo, UT

Biological control agents have become increasingly important in integrated pest management programs. However, certain traits of these agents that are needed for efficient biocontrol often decrease or are lost during *in vitro* rearing. Entomopathogenic nematodes (EPNs) are biocontrol agents that kill their insect targets with the help of a symbiotic bacterium. EPNs and their bacterial symbionts often exhibit trait deterioration when reared under laboratory conditions. EPN trait deterioration has most often been attributed to genetic causes; however, it is still unclear what the underlying causes of trait deterioration are in the bacterial endosymbiont. In this study the EPN symbiont *Photorhabdus* was monitored for the deterioration of three traits; inclusion body production, reproductive potential, and virulence, in three different environments; lipid liquid medium (LLM), nutrient broth (NB), and tryptic soy broth+yeast extract (TSY). Significant trait deterioration did not occur for any of the traits in any environment. However, there was an increase in inclusion body production in TSY. Additionally, one of the sub-cultured biological replicates of TSY was less virulent than the other two. However, returning bacteria cultured in TSY to LLM restored virulence to wild-type levels. We infer the observed trait deterioration in *Photorhabdus* to be driven by environmental conditions as opposed to stable genetic changes. Our data suggest that variation among important biological control traits of *in vitro* cultures of *Photorhabdus luminescens* is more likely due to environmental variation than inadvertent laboratory selection.

P115 Public Tick IPM Working Group

Thomas A. Green[1], *Chloe L. Nelson[1], cnelson@ipminstitute.org, and Thomas N. Mather[2]

[1]IPM Institute of North America, Inc., Madison, WI; [2]Center for Vector-Borne Disease, University of Rhode Island, Kingston, RI

Eleven of the seventeen tick-borne diseases in the US are known to infect humans, with Lyme disease accounting for over 90% of all reported vector-borne diseases. Rapid expansion of tick populations throughout the North Central and other regions in the US poses a serious threat to public health due to increased exposure and tick-borne disease incidence. CDC estimates 300,000 diagnosed cases each year with increasing incidence. The Public Tick IPM Working Group formed in 2013 to create a forum for improving communications, networking and collaboration amongst all interested parties interested in supporting tick IPM. The primary goal of the group is to reduce tick-borne disease incidence by collaborating on IPM-related activities and efforts that will ultimately reduce the risk of exposure to ticks and subsequent pathogens. IPM-based prevention is critical in tick management since human, animal and environmental health are important concerns in tick-infested areas including public parks or schools where chemically based management practices pose health risks to humans and the environment. The Working Group scope includes all IPM strategies including vaccines designed to reduce tick numbers or block the ability of ticks to transmit pathogens in the US and Canada. Since its formation, we have recruited ninety-six individuals to join the Public Tick IPM Working Group listserv, hosted several guest speakers on educational and technological topics on our monthly conference call and created a database to track federal funding

for tick-related projects with funding from the USDA North Central IPM Center.

P116 not presented

P117 Western Region Tribal IPM Work Group: Learning to maintain forest health to sustain tribal values

Janice Alexander[1], *Nina Hapner[2], nina@stewartspoint.org, Susan Frankel[3], Carla Thomas[4], and Marcy Katzin[5]

[1]University of California Cooperative Extension, Marin County, Novato, CA; [2]Kashia Band of Pomo Indians, Santa Rosa, CA; [3]USDA Forest Service, Pacific Southwest Research Station, Albany, CA; [4]National Plant Diagnostic Network, Davis, CA; [5]Environmental Protection Agency, San Francisco, CA

Forest health is a critical issue to tribes given that many forest species are vital sources of culturally significant foods, fibers, ceremonial objects, and medicines. Tribal members typically comprise a small percentage of regional populations so their values may not be well represented in conventional land management practices. We focus on IPM of invasive species that affect natural resources integral to tribal culture and daily life. We work cooperatively to better understand how pests move; find management solutions that minimize impacts; and ultimately sustain native natural resources and values. We've held six Work Group sessions, bringing together diverse groups to focus on local IPM topics. Of greatest concern are management techniques that protect tribal values, including: the safe use of pesticides, reintroducing fire as a management tool, proper sanitation, and best management practices; protection from invasive insects and diseases such as the goldspotted oak borer (*Agrilus coxalis*), polyphagous shot hole borer (*Euwallacea* sp.), sudden oak death (*Phytophthora ramorum*), and laurel wilt (*Raffaelea lauricola*); control of numerous weeds; identifying and eliminating newly established invasive species; and incorporating Traditional Ecological Knowledge practices back into wildland management. This year we will use a citizen science approach to map the distribution of *P. ramorum* on infested tribal lands and traditional gathering areas; conduct pest-specific field training for tribes in Southern and Northern California; and we plan to create a tribal pest identification and management field guide. For more information on the Western Region Tribal IPM Work Group see http://www.wrpmc.ucdavis.edu/TribalIPMworkgroup.html.

P118 The IR-4 Public Health Pesticides Inventory—A new tool for integrated vector management

Karl Malamud-Roam and *Jerry Baron, jbaron@aesop.rutgers.edu

IR-4 Project, Rutgers University, Princeton, NJ

An essential element of any effective IPM program is a data management system that identifies the tools available for controlling key pest(s) and provides information on use patterns, regulatory status, bioactivity vs. distinct pest life stages, risks to health or the environment, availability, physico-chemical attributes, and other key attributes of available control tools. This is essential for selecting the right tool for a particular job, as well as for evaluating risks to the current tool box posed by pending regulatory or business changes. In addition, an inventory of potentially useful tools that are not currently in use can help focus research, product development, regulatory actions, and testing and evaluation to ensure that future needs will be met. The IR-4 Project, a collaboration of US federal and state agencies, has recently published an Inventory of Public Health Pesticides, focusing on chemical tools to control mosquitoes, ticks, and sandflies, that aggregates such information on over 1200 vector control materials used around the world, or with potential for use in vector control. The Inventory is available at http://ir4.rutgers.edu/PublicHealth/PHP%20Inventory.pdf, and a searchable on-line version is at http://ir4.rutgers.edu/PublicHealth/publichealthDB.cfm. A Second Edition of the Inventory and an expanded website, both with information on end-use products and product classes as well as on specific chemicals and mixtures, will be released in 2015.

P119 Extension outreach tools for invasive pests and diseases

*Mary K. Malinoski[1], mkmal@umd.edu, David L. Clement[1], and Chuck T. Bargeron[2]

[1]University of Maryland Extension, Ellicott City, MD; [2]Center for Invasive Species and Ecosystem Health, University of Georgia, Tifton, GA

Our nation's natural resources and ecosystems are under constant pressures from encroaching invasive species. The development of Smartphone apps and field ID cards increases the possibility of early detection of new or invasive insects and diseases helping safeguard the environment and reducing the overall costs of successful management. Nationally, insects such as emerald ash borer and Asian longhorned beetle are causing serious problems for the environment, Green Industry and private land owners. While precise economic impact is not known, estimates range in the tens of millions of dollars. Impacts include degradation of environmental quality, loss and quarantine of nursery crops, decreased property values, monitoring and eradication costs, and losses of recreational and aesthetic value. Smartphone apps allow users to compare photos and descriptions to field conditions while still in the field without any additional tools or equipment. They also allow sending of first reports and pictures along with precise GPS location for further confirmation by regulatory officials. Apps and ID cards are readily available to Extension, Regulatory and Green Industry professionals as well as lay citizens further increasing the possibility of early accurate detection.

Field ID cards also allow users to compare photos and descriptions of target species leading to fewer false reports.

P120 Caught with your plants down? Get an app for that at PurduePlantDoctor.com

Clifford S. Sadof[1], Janna Beckerman[2], *Ricky Foster[1], rfoster@purdue.edu, John Obermeyer[1], and Lindsey Purcell[3]

[1]Department of Entomology; [2]Department of Botany and Plant Pathology; [3]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN

The potential for pesticide misuse in the urban landscape is staggering. Consumers support a $74 billion industry staffed with nearly 1 million workers to install and maintain landscapes. Each year over 80 million untrained homeowners purchase over 130 million pounds of pesticides for use in gardens. Teaching this diverse group to protect hundreds of plant species from hundreds of plant problems through traditional venues poses a real challenge for Extension. Advances in smartphone technology provides an opportunity to efficiently reach this audience by providing them concise information in their moment of need. The Purdue Plant Doctor App series is designed to help homeowners and professionals in the Midwest and the Northeastern States identify problems and learn how to resolve them with IPM practices including cultural and chemical tools. We use an intuitive photo driven interface to rapidly guide each user to a diagnosis on each of our 4 Apps. The Purdue Tree Doctor alone has over 1000 high quality images that help users identify over 180 plant disorders on over 60 genera of trees. Apps sell for less then $2 each and are available from the App Store for the I-Phone and Google Play for Android devices. They run on both smartphones and tablets that use Apple IOS and Android operating systems. Once purchased, Apps are automatically updated after Extension Specialists edit content on a centrally stored secure server. Over 7K apps have been sold to date.

P121 Nevada extension public survey supports targeted approach to IPM education

*Heidi A. Kratsch, kratschh@unce.unr.edu, JoAnne Skelly, and Susan Donaldson

University of Nevada Cooperative Extension, Reno, NV

IPM education is critical to reducing misuse of pesticides, which can result in increased personal exposure to pesticides and nonpoint source pollution of waterways. Survey results from other states indicate people gain familiarity with the term IPM as a result of exposure to a variety of sources. The Nevada Extension Urban IPM team completed a survey of the general public and an identical but separate survey of master gardeners in four Nevada counties. Our goal was to compare their attitudes and behaviors related to IPM to more efficiently reach different educational populations with targeted IPM messages. We found greater than 90 percent of master gardener respondents had heard of IPM and were likely to use IPM practices, while only 10 percent of general public respondents had heard of IPM. General public respondents were more likely to consider rapid results important when purchasing pesticide products than were master gardener respondents, and master gardener respondents placed more importance on pesticide safety than did general public respondents. While 64 percent of master gardener respondents were likely to use Nevada Extension sources for information on pest problems, only 7 percent of general public respondents use these sources. Our results demonstrate the value of master gardeners as allies in educating the general public about IPM, but multiple approaches are needed to expand our message to greater numbers of Nevadans. We have used the survey results to develop behavior-specific IPM messages to be delivered by a variety of face-to-face, point-of-sale, print, web-based and broadcast media venues.

P122 Yearly distribution (2007-2014) of tamarisk beetle, a biocontrol agent

Ben Bloodworth, bbloodworth@tamariskcoalition.org

Tamarisk Coalition, Grand Junction, CO

The tamarisk beetle (*Diorhabda* spp.) was studied by USDA and approved for release as a biocontrol agent for the invasive riparian shrub, tamarisk (*Tamarix* spp.). Since its first approved field release in 2004, this agent has spread rapidly across the landscape through natural population expansion and purposeful human introduction. In 2007, Tamarisk Coalition began monitoring population expansion and now works with more than 50 partners across 11 states and Mexico to track the spread of the beetle. There are now four different tamarisk beetle species actively moving across the landscape of western North America, and established beetle populations range from Chihuahua, Mexico, to California, north into Oregon, Idaho, Wyoming, and east into Kansas and Oklahoma. Some of these beetle populations are pushing into areas where concerns over wildlife habitat, livestock utilization, threatened and endangered species, and bank stabilization are arising. Tracking population movement and providing an annual map of this progression has been a valuable tool for land managers and producers as they consider ways to incorporate the beetle into their integrated pest management strategies.

P123 Effects of parasitoid and floral diversity on parasitism of a sagebrush defoliating moth across a montane landscape

*Virginia L. J. Bolshakova[1], vbolshakova@ucanr.edu, and Edward (Ted) W. Evans[2]

[1]University of California Cooperative Extension, San Mateo & San Francisco Counties, UC Elkus Ranch, Half Moon Bay, CA; [2]Department of Biology, Utah State University, Logan, UT

Species diversity of natural enemies is hypothesized to promote suppression of insect herbivores. We examined patterns of abundance along an altitudinal gradient for a sagebrush defoliator, Aroga moth (*Aroga websteri* Clarke; Lepidoptera: Gelechiidae), and the parasitoid species guild attacking the moth and the community of flowering understory plants that may provide critical food for these parasitoids. The study was conducted throughout a 5700 hectare wildlife management area in a sagebrush steppe ecosystem dominated by *Artemesia tridentate*, big sagebrush. Over the course of four years (2008-2011), we found three major parasitoid species to differ strongly and predictably in attacking the moth along elevation clines, with greatest overall parasitism occurring when all three species were present. Floral species richness increased strongly from low-to-high elevation and was correlated with rates of parasitism by two major parasitoid species. Over a more limited range (mid-to-high elevation), parasitism of the moth was correlated with floral species richness, but neither parasitism nor floral species richness was correlated with elevation. Field experiments revealed that two species of pupal parasitoids responded differently to provisions of floral resources and methyl salicylate (an HIPV). Even as the presence of all major parasitoids together led to greatest parasitism rates, individual species of parasitoids differed substantially and complemented one another in their patterns of attack among local populations of Aroga moth across the montane landscape. Overall, the results of this study support the hypothesis that over large scales of space and time, species diversity of natural enemies promotes suppression of insect herbivores.

P124 Biological control options for invasive weeds in Nevada

Joy Paterson[1], *Jay Davison[2], davisonj@unce.unr.edu, and Jeff Knight[3]

[1]University of Nevada Reno, Cooperative Extension, Yerington, NV; [2]University of Nevada Reno, Cooperative Extension, Fallon, NV; [3]Nevada Department of Agriculture, Reno, NV

This joint publication produced by the University of Nevada Reno Cooperative Extension and Nevada Department of Agriculture updates an earlier publication aimed at informing Nevada agricultural producers and land managers about current biological control options for noxious or invasive weeds found in Nevada. It was published in response to numerous requests for information regarding biological control options from agricultural producers and land managers facing the ever increasing threat posed by noxious and invasive weeds. The publication details the role of biological control agents in an Integrated Pest Management (IPM) Program for invasive weeds. The publication includes sections on; 1) understanding biological control programs, 2) the role of livestock grazing in a biological control program, 3) the factors underlying a traditional biological control program using insects, 4) the legal and procedural steps that must be taken in Nevada before implementing a biological control program and 5) a comprehensive list of invasive weeds found in Nevada with potential insect agents recommended for use in a control program.

P125 Temperature, moisture, and herbicide effects on germination of Dyer's woad seeds

*James J. Stapleton[1], jjstapleton@ucanr.edu, Steve B. Orloff[2], and Nicole O. Luiz[2]

[1]Statewide IPM Program, University of California Kearney Agricultural Center, Parlier, CA; [2]UC Cooperative Extension, Yreka, CA

Dyer's woad (*Isatis tinctoria*), a member of the mustard family, is a problematic, invasive weed in the intermountain west, including northern California. Although it can be controlled by properly-timed herbicide applications, further spread along roadsides and in isolated areas is occurring. Research during 2012-14 has shown that some seeds become germinable at early stages of seed set, and the proportion increases over the period of maturation. Preliminary herbicide trials with glyphosate or 2,4-D at late bloom or during seed maturation showed that such delayed applications may not prevent viable seed production and subsequent germination. Additional studies were initiated to examine the feasibility of integrated pest management using solar tents to eliminate viable seeds on senescent skeleton plants in small stands of woad. Moistened seeds, enclosed within silicles, were susceptible to effects of high temperature. Preliminary data showed seed germination to be completely inhibited by 20 min exposure to 70 C; 75 min to 60 C; and 28 hr to 50 C. The silicle covering provided protection to seeds against heat exposure, especially at the lower temperatures tested. Field experiments were conducted during summer months in Scott Valley, Siskiyou County, California to test effects of seed incubation in solar tents on germination. The trials indicated that germination of seed lots completely immersed in water could be greatly reduced in solar tents.

P126 *Hypena opulenta*: The first biological control agent released for control of swallow-worts in North America

*Lisa Tewksbury[1], lisat@uri.edu, Richard Casagrande[1], Robert Bourchier[2], Aaron Weed[3], and Andre Gassmann[4]

[1]Department of Plant Science and Entomology, University of Rhode Island, Kingston, RI; [2]Biological Control/Lutte Biologique, Agriculture and Agri-Food Canada-Lethbridge Research Centre, South

Lethbridge, AB, CA; [3]Biological Sciences, Dartmouth College, Hanover, NH; [4]CABI, Delemont, Switzerland

Two species of European swallow-wort, *Vincetoxicum nigrum* and *Vincetoxicum rossicum* (Apocynaceae), have become invasive in North America, where there are no effective natural enemies able to suppress populations and deter further spread. The use of conventional control methods is largely unsuccessful in managing established infestations, and biological control appears to be the most promising alternative. The European leaf-feeding moth, *Hypena opulenta* (Lepidoptera: Erebidae) has demonstrated potential for successful biological control of swallow-worts. Host range testing with an approved TAG list of 76 plants using no-choice larval development has shown that the larvae of *H. opulenta* are monophagous on *Vincetoxicum* species and thus pose no risk to any native North American plant species or any other species of economic importance. *Hypena opulenta* caused extensive defoliation of *V. nigrum* and *V. rossicum* under laboratory conditions in quarantine, and it is expected that this multivoltine species will adversely impact the spread, seed production and biomass of swallow-worts under field conditions with repeated defoliation and in the presence of competing plant species. We petitioned for the open-field release of *H. opulenta* as a biological control agent for *V. nigrum* and *V. rossicum* in the United States and Canada in 2012. The petition was granted for Canada and an overwintering release was made near Ottawa in September 2013. The United States petition was approved by TAG and a release permit is awaiting approval.

P127 Pine engraver beetles invade the Sonoran Desert

*Peter Warren, plwarren@cals.arizona.edu, Ursula Schuch, and Tanya Quist

University of Arizona, Tucson, AZ

Pine engraver beetle refers to 11 species of insects in the *Ips* genus that live in the inner bark of pine trees that can cause rapid decline and death of pine trees. Typically, these insects are found in higher elevations (4200 to 9000 feet) but have recently been detected at about 2400 feet in Tucson. The six-spined engraver (*Ips calligraphus*) has been the only species detected, so far, in Tucson. This is the first time these native bark beetles have been found in non-native pines in the Sonoran Desert.

P128 A semiochemical-based tool for protecting pines from mortality attributed to bark beetles

Christopher J. Fettig[1], A. Steven Munson[2], Brittany Poirson[3], and *Agenor Mafra-Neto[3], president@iscatech.com

[1]Pacific Southwest Research Station, USDA Forest Service, Davis, CA; [2]Forest Health Protection, USDA Forest Service, Ogden, UT; [3]ISCA Technologies Inc., Riverside, CA

Verbenone (4,6,6-trimethylbicyclo[3.1.1]hept-3-en-2-one) is the principle antiaggregation pheromone of several bark beetles capable of causing significant levels of tree mortality in the US A novel formulation of (–)-verbenone was developed (SPLAT® Verb) and evaluated for protecting individual lodgepole pine, *Pinus contorta*, and small stands of lodgepole pine from mortality attributed to mountain pine beetle (MPB), *Dendroctonus ponderosae*. Applications of prototypes of SPLAT® Verb to individual lodgepole pines resulted in complete tree protection while 93.3% mortality was observed in the untreated controls in two studies. In the second study, significantly fewer lodgepole pine were killed by MPB within 0.041-ha circular plots (11-m radius) surrounding trees treated with SPLAT® Verb compared to the untreated control. In a third study, a smaller percentage of lodgepole pine were colonized and killed on 0.4-ha plots treated with SPLAT® Verb compared to the untreated control. In a trapping bioassay, no significant differences were observed among captures at 1, 2 or 4 m for the point of release of SPLAT® Verb. Significantly fewer MPB were collected at 1 and 2 m compared to 8 m. Significantly more MPB were captured at the farthest distance evaluated (16 m) than at any other distance, suggesting the zone of inhibition of SPLAT® Verb-point sources exceeds 8 m. Current research with SPLAT® Verb focuses on refining release rates and evaluating efficacy in other forests (e.g., ponderosa pine, *P. ponderosae*) and development of similar tools for other bark beetles (e.g., western pine beetle, *D. brevicomis* and southern pine beetle, *D. frontalis*).

P129 The integrated management of bark beetles in conifer forests

*Christopher J. Fettig[1], cfettig@fs.fed.us, Jacek Hilszczański[2], Horst Delb[3], and A. Steven Munson[4]

[1]USDA-FS, Pacific Southwest Research Station, Davis, CA; [2]Forest Research Institute, Department of Forest Protection, Sękocin Stary, Raszyn, Poland; [3]Forest Research Institute of Baden-Württemberg, Forest Health, Freiburg, Germany; [4]USDA-FS, Forest Health Protection, Ogden, UT

Bark beetles (Coleoptera: Curculionidae, Scolytinae), a diverse group of insects consisting of greater than 6,000 species worldwide, are commonly recognized as important tree mortality agents. We review tactics available for reducing levels of tree mortality attributed to bark beetles in conifer forests while comparing management practices for mountain pine beetle, *Dendroctonus ponderosae* Hopkins, in western North America, and spruce beetle, *Ips typographus* (L.), in central Europe. Both *D. ponderosae* and *I. typographus* are among the most destructive of all forest insect pests. In recent years, outbreaks of *D. ponderosae* have been particularly severe, long lasting, and well-documented, with >27 million hectares and several tree species impacted. *Ips typographus* is regarded as the most important pest of Norway spruce, *Picea abies*

(L.) Karst., an indigenous tree species in Europe also widely cultivated for commercial timber production outside its native range. Outbreaks of *I. typographus* are usually precipitated by other disturbances such as windstorms, and may result in mortality of thousands of trees annually.

P130 First record of the velvet longhorn beetle (*Trichoferus campestris* Faldermann) from Utah

Clinton E. Burfitt, *Kristopher Watson, kwatson@utah.gov, Caressa A. Pratt, and *Joey Caputo, jcaputo@utah.gov

Utah Department of Agriculture and Food, Plant Industry and Conservation, Salt Lake City, UT

The velvet longhorn beetle (*Trichoferus campestris* Faldermann) is a potential threat to Utah's urban, orchard, and riparian woodland areas. Trapping protocols and actions taken in association with the detection effort are necessary to maintain healthy urban and forest ecosystems. Expanded detection trapping along natural waterways and orchards indicate that the insect's infestation, first discovered in South Salt Lake City in July 2010, is widespread in Salt Lake and Utah counties. The velvet longhorn beetle (VLB) was first detected in North America in the province of Quebec, Canada in 2002 (Grebennifov et al. 2010). It has been found in warehouse settings in Ohio (2009), Rhode Island (2006), New Jersey (2007), and Illinois (2009) (Blackwood 2010). Exotic wood borers such as the VLB spread into new areas through infested wood packing material that accompanies a wide variety of imported commodities such as: building supplies, machinery, tools, glass, tiles, etc. Published reports from the European Plant Protection Organization, CABI and Global Pest Disease Database have been summarized in the USDA-APHIS-National Identification Services Plant Pest Risk Assessment (1998). The conclusion of this literature review is that the VLB is polyphagous and prefers to attack apple (Malus), and mulberry (Morus) in its native range. Integrated Pest Management (IPM) strategies to control this insect are in development by the Utah Department of Agriculture and Food (UDAF). Preliminary recommendations include limiting the movement of wood and maintaining hygienic cull piles. Future IPM protocol will be informed by research being jointly conducted by UDAF and APHIS PPQ CPSHT.

P131 How destructive is brown marmorated stink bug to herbaceous perennial plants

*Stanton Gill[1], sgill@umd.edu, Brian Kunkel[2], Karen Rane[3], Suzanne Klick[1], and Debby Smith-Fiola[4]

[1]University of Maryland Extension, Central Maryland Research and Education Center, Ellicott City, MD; [2]University of Delaware Extension, Newark, DE; [3]Plant Diagnostic Laboratory, College Park, MD; [4]Landscape IPM Enterprises, LLC, Keedysville, MD

The brown marmorated stink bug (BMSB) is rapidly expanding its territory and this invasive species has developed a palate for many species of plants. The pest has spread to more than 40 states where it has been found feeding on a number of species not recorded in its native habitat in Asia. Furthermore, their populations are frequently numerous enough to cause significant economic injury to many agricultural crops, but little is known about economic threats to ornamental plants. BMSB adults have been observed feeding on flowers and seed pods of several ornamental herbaceous plants, but the damage to flowers, seed pods, stems and leaves has not been documented. Disease transmission from BMSB feedings on herbaceous plants has not been confirmed in the literature. Because of this dearth of knowledge, our team of researchers launched a study to determine if BMSB was a significant pest of herbaceous perennial plants growing in commercial perennial plant production nurseries. Trials were conducted at nurseries in Maryland and Pennsylvania in 2012. Our results show limited damage to herbaceous perennials. A list of potential target herbaceous perennials has been developed.

P132 Conducting 21 turfgrass IPM educational seminars in a single day

*Fred Fishel[1], weeddr@ufl.edu, and Pete Snyder[2]

[1]Department of Agronomy, University of Florida, Gainesville, FL; [2]Florida Turfgrass Association, Lakeland, FL

Managing pests of turfgrass has long been identified as a priority need for the turfgrass industry in Florida. Since 2012, an annual, single-day educational event has been held for managers of turfgrass as the primary audience. The use of Polycom® has allowed the event to be broadcast from the University of Florida's main campus to county extension offices throughout the state. Our 2014 event was hosted by 21 of these sites, attracting 472 attendees, most of who work in some facet of the turfgrass industry. The majority of those in this industry also are state-licensed pesticide applicators; thus, such an event provides an opportunity to offer continuing education credit for license renewal. The focus of the 2014 event was IPM of weeds, including biological weed control, herbicide technology, managing resistance, and minimizing drift to sensitive areas. Participant survey results indicate that the majority of this audience gained knowledge by attending the event, plan to adopt at least one recommended practice, and the knowledge gained from the event will help their job performance. From an extension educator's viewpoint, a positive outcome was that those attending were comfortable with participating in a distance-delivered educational program.

P133 High-level IPM at Cooperstown's Doubleday Field

*Joellen M. Lampman[1], jkz6@cornell.edu, and Quinton Hasak[2]

[1]NYS IPM Program, Cornell University, Albany, NY; [2]Doubleday Field, Cooperstown, NY

Doubleday Field is a much loved, historic ball field owned by the Village of Cooperstown, which has set a policy to try to eliminate pesticide use on Village property, but without establishing an IPM plan of action. The ball field is subjected to intense traffic, hosting over 300 games a year, rain or shine, as well as community events. With the support of the NYS IPM Program, Doubleday Field was managed during the 2012 season using high-level IPM. Many of these practices continued under new management in 2013. In 2014, NYS IPM Program support officially resumed. Adherence to the core cultural practices of mowing, fertilizing, and irrigating, during a year that was particularly conducive to turfgrass growth, provided a relatively pest free playing field. Weeds in the warning track and under the bleachers caused issues throughout the growing season, but the addition of warning track material and manual raking and flaming kept these issues under threshold levels. It is clear that, especially during a good year, acceptable playing conditions can be achieved without the use of pesticides; however, the conducive conditions also masked consequences that might have become evident due to the lack of appropriate equipment and staffing. A commitment to pesticide free maintenance must be coupled with a commitment to providing the resources needed to allow all cultural practices to be completed at the appropriate time.

P134 "Lawn Care: The Easiest Steps to An Attractive Environmental Asset" ibook resource

Lori J. Brewer ljb7@cornell.edu

Cornell Garden-Based Learning Program, Horticulture, Cornell University, Ithaca, NY

With more than 40 million acres of lawns in the United States, what we do with our lawns matters. Effectively connecting green industry professionals and lawn owners with the best lawn care practices is a critical step in cultivating lawns as environmental assets. "Lawn Care: The Easiest Steps to An Attractive Environmental Asset" free ibook highlights the expertise of the Cornell Turfgrass team research team. Seven short how-to videos are a key feature. Additionally, photo galleries, interactive images and concise directions make understanding the steps to cultivating a healthy lawn that is an attractive environmental asset quick and easy. Links allow the viewer to easily flip to different section of the book as well as connect with numerous supplemental web-based resources for more in depth information and connection with their local Cooperative Extension network. Guidance is also provided on advanced lawn care including addressing problem areas and creating a new lawn. A Pew Research Center study revealed that some 43% of Americans age 16 and older say they have either read an ebook in the past year or have read other long-form content such as magazines, journals, and news articles in digital format on an e-book reader, tablet computer, regular computer, or cell phone. Creating this ebook allows us to gain experience in ebook production which provides an opportunity to remain current and connected with our traditional and new audiences.

P135 not presented

P136 Tracking billbugs to improve IPM in intermountain west turfgrass

*Ricardo A. Ramirez, ricardo.ramirez@usu.edu, and Madeleine Dupuy

Department of Biology, Utah State University, Logan, UT

Billbugs (*Sphenophorus* spp.) are damaging weevil pests of turfgrass in the Intermountain West. Most of what is known about billbug phenology comes from studies done on bluegrass billbug in the eastern US, and several aspects of their biology have yet to be validated in our region. Current management consists of prophylactic applications of neonicotinoid and diamide insecticides. Understanding the seasonal activity of billbugs in turfgrass will help to improve management by offering information about the appropriate timing of traditional and alternative management tactics. Adult billbugs were sampled weekly using linear pitfall traps on four golf courses in Idaho and Utah. The damaging larval stages were sampled once every two weeks by collecting soil cores. We found a complex of three species including bluegrass, hunting, and Rocky Mountain billbugs. The eastern model predicts first adult occurrence between 280 and 352 DD50. However, we observed first occurrence between 16 and 20 DD50—several weeks earlier than the current model. Adult activity peaked in late May (318-444 DD50). Eggs were deposited in late May, and the larval stages were most abundant in late June to early July. Given the differences in billbug activity among sites, factors such as elevation and soil moisture are being evaluated to explain the variation in billbug populations. These data are currently being used to develop a degree-day model adapted for management of billbugs in the Intermountain West.

P137 Development of the University of Alaska Fairbanks integrated invasive plant management plan

Marie E. Heidemann[1], *Steven S. Seefeldt[1], ssseefeldt@alaska.edu, Susan Todd[1], and Tricia Wurtz[2]

[1]Department of High Latitude Agriculture, University of Alaska Fairbanks, Fairbanks, AK; [2]US Forest Service, Fairbanks, AK

The University of Alaska Fairbanks Campus has a variety of invasive plants, many of which were introduced by UAF researchers and landscaping professionals. Impacts of invasive plants to the UAF campus extend beyond landscaping to recreational users, reindeer and other research animal health, research activities, and aesthetics. Several individuals recognized the need for committed invasive plant management on the UAF Campus. In 2009 the US Forest Service Forest Health and Protection and UAF School of Natural Resources provided funding for the development of the UAF Campus Invasive Plant Management Plan. The plan was developed through a task-force process with 13 representative members of campus. An initial scoping process included interviews with task force members and other interested individuals to identify issues the plan should address. Task force members attended meetings from February through May 2010 to discuss these issues and make recommendations for invasive plant management on the UAF Campus. A public meeting was held to present a draft of the plan and gather public input. The final draft of the plan was written based on the agreements the task force developed in their meetings. The resulting integrated management plan was accepted as an addendum to the Campus Landscape Plan. The primary goals of the plan include focusing on best management practices, education and awareness, and management of existing infestations. The UAF Campus Invasive Plant Management Plan provides campus land managers with clear guidelines and management priorities to reduce current invasive plant infestations and prevent the establishment of new invasive plants.

P138 Phone apps and websites as tools for pesticide reduction in yards and gardens

*Lisa Niehaus[1], lisa.niehaus@kingcounty.gov, Lien Jardine[1], Lisa Heigh[2], Patrick Soderberg[3], Carl Grimm[2], and Jane Mount Joy-Venning[3]

[1]Local Hazardous Waste Management Program, King County, WA; [2]Metro, Portland, OR; [3]Thurston County Environmental Health, Olympia, WA

Grow Smart, Grow Safe® (GSGS) is a gardener's guide to choosing safer garden products. The information is available free on a website and a phone app. It is difficult for a layperson to access reliable, consistent pesticide research information. It's time consuming to make comparisons. People want to choose products that are safer to use where their children and pets play and for the environment. GSGS makes it easier for them to do that. Gardening without pesticides is the safest choice and GSGS also provides great information about Natural Yard Care and pesticide-free gardening. GSGS is an online searchable database at www.GrowSmartGrowSafe.org and Grow Smart is a free cell phone App for iPhones. GSGS reviews research about pesticide active ingredients and surveys store shelves to see what is available in our region, by product name. We combine those two sets of information into a list of pesticides with the safer ones at the top on down to those with more health or environmental concerns. Research for ranking pesticide products comes from Thurston County's Integrated Pest Management (IPM) program. Product information is collected by doing shelf surveys in each jurisdiction. Registration information is cross-checked against the Washington State Department of Agriculture pesticide information database. GSGS resources will continue to grow with Android versions of the App, eBook capability and new print versions based on the database. Providing accurate and useful information with an easy-to-use, technically-advanced tool provides gardeners with a way to choose safer pesticides with confidence.

P139 Promoting and teaching IPM as smart gardening

*Joy N. Landis[1], landisj@msu.edu, Rebecca Finneran[2], Mary Wilson[3], Mallory Fournier[1], and Dave Smitley[4]

[1]Michigan State University IPM Program, Department of Entomology, East Lansing, MI; [2]Michigan State University Extension, Consumer Horticulture, Grand Rapids, MI; [3]Michigan State University Extension, Master Gardener Program, Novi, MI; [4]Michigan State University, Department of Entomology, East Lansing, MI

Science-based gardening, environmental awareness and sustainability have long been a hallmark of our MSU Extension programs, yet somehow these messages were not getting through to home gardeners. MSU's landscape extension entomologist noted that landscape professionals were responding to advice to set mowers on their highest setting for IPM and other benefits, however homeowners were not. This prompted communicators to recommend repetitive, consistent use of a small number of concise messages for gardeners. These types of messages were a natural fit with programming envisioned by MSU's consumer horticulture team. Our goal became to communicate three messages rooted in IPM as simple ways to start "Smart Gardening:" (1) Smart lawns—Mow at the highest setting to promote deep roots, avoid grub damage and crowd out weeds. (2) Smart plants—Select plants, trees and shrubs that are native or well-adapted to challenges by pests and local conditions. (3) Smart soils—Test the soil to use money and soil wisely by fertilizing only as needed per test results. We used these as stand-alone messages and also embedded them in more comprehensive programs such as education at home/garden shows attended by 60,000+ people. Results include calls to our garden hotline grew 20% and website visits have increased 25%; surveys of participants at a Grand Rapids location indicate 69% used a soil test, 90% raised their mowing height, and 91% installed native plants; MSU sales of soil test kits were up 203% with 3,433 sold in 2013.

P140 not presented

P141 Developing a straightforward index to track pesticide impacts over time based on San Francisco's Hazard Tier system

*Rosemarie Radford[1], rose@pesticideresearch.com, Chris Geiger[2], and Susan Kegley[1]

[1]Pesticide Research Institute, Berkeley, CA; [2]San Francisco Department of the Environment, San Francisco, CA

Metrics for measuring the success of an IPM program are typically limited to pounds of pesticide products or active ingredients used; however, these measures do not correlate well with actual environmental and human health risks. Some efforts to improve pesticide impact assessment rely on detailed quantifications of multiple, often site-specific variables. While such tools are useful for individual users, their data requirements and complexity may make them impractical for non-specialists or for broad, programmatic evaluations. Other efforts to estimate pesticide impact rely strictly on active ingredient hazards, without including hazards of so-called "inert" ingredients. We have developed a straightforward index that provides a measure of pesticide impact based both on product hazards and the total pounds used. Product hazard is characterized using the San Francisco Hazard Tier approach, which accounts for both active and other identified ingredients, and includes both label and MSDS information. Each product is assigned a hazard score based on four components: Environmental impact; human acute impact; human chronic impact; and environmental fate. The impact index for each hazard type is determined by multiplying hazard scores by pounds of product used. While not a formal quantification of risk, this approach is transparent, simple to use, includes all readily available hazard data, and provides a great improvement over more typical metrics in tracking pesticide impact over time. Examples using City of San Francisco data will be discussed.

P142 National Pesticide Information Center: 20 years of science-based conversations

Amy Hallman, Laura Hickerson, *Kaci Buhl, buhlk@ace.orst.edu, and Dave Stone

National Pesticide Information Center (NPIC), Department of Environmental & Molecular Toxicology, Oregon State University Corvallis Campus, Corvallis, OR

Since 1995, the National Pesticide Information Center has provided objective, science-based information about pesticides to enable informed decision-making. Pesticide specialists at Oregon State University have responded to >340,000 inquiries by phone (1-800-858-PEST), email (npic@ace.orst.edu), and lately, through social media channels. The Center benefits from interacting with the public, honing communication methods over time. They incorporate that knowledge into publications, podcasts, and videos that are easy to understand. NPIC publications promote safe use practices, integrated pest management, and pesticide label comprehension. Specialists have advanced degrees in science and training in risk communication. NPIC has developed five mobile web apps to date, including a pesticide product search tool and a resource directory containing over 3,000 contacts for local experts.

P143 BugGuide as a model for crowdsourcing extension diagnostics

*Laura C. Jesse[1], ljesse@iastate.edu, John K. VanDyk[1], and Daren S. Mueller[2]

[1]Department of Plant Pathology, Iowa State University, Ames, IA; [2]Department of Entomology, Iowa State University, Ames, IA

Correct diagnosis of a problem is the first step in implementing an integrated pest management (IPM) program. Most land-grant universities have faculty or staff identifying insect pests, plant diseases, mushrooms, plants and more. As mobile devices become ubiquitous, people are collecting information and learning about their world in a whole new way. Identifying a pretty flower now only requires a quick picture and email or text to an extension specialist. Extension personnel are hard-pressed to keep up with the pictures filling our inboxes asking things like what is this that bit me? or why is this part of my field stunted? Email with attached pictures is the primary way many extension specialists handle these questions, but is it the best way? Platforms like BugGuide enable us to engage with our clients and simultaneously share information more widely, allowing many people to join the discussion. This broadens impact and educational value. BugGuide identifies an average of 17,000 insects monthly during the summer. Pictures of insects are organized taxonomically and information is written about each taxon level. Dedicated, unpaid volunteers and moderators accomplish all of the identifications and organization. Platforms like BugGuide have the potential to revolutionize extension diagnostics and allow diagnostics to better integrate into efforts such as pre-collegiate STEM curriculum. Next we will expand this platform into plant disease diagnostics, plant and mushroom identification, and more.

P144 Stored product beetles: How physical and biological factors affect residual efficacy of insecticides

*Sharon M. Dobesh[1], sdobesh@ksu.edu, and Frank H. Arthur[2]

[1]Kansas State University, Department of Plant Pathology; [2]USDA-ARS, Center for Grain and Animal Health Research Unit, Manhattan, KS

Two formulations of the insecticide chlorfenapyr (Phantom SC or PI) were evaluated for control of the red flour beetle

(*Tribolium castaneum* Herbst) and warehouse beetle (*Trogoderma variable* Ballion). Studies were done by first constructing concrete exposure arenas in 15 cm plastic Petri dishes; these arenas consisted of a solid concrete arena or one in which a crevice was created in the center of the arena. The insecticide formulations were then applied to the entire surface, to the crevice only, to the entire surface except for the crevice, or to the surface and crevice with food in the crevice. An untreated control was also included. Adults of each species were exposed for 8 hours and 1, 2, 3 and 4 days on the arenas. Survival was assessed daily but only the final counts at day 4 are presented. Phantom PI had more residual efficacy than Phantom EC but there was no difference in response between laboratory strains of the red flour beetle and the warehouse beetle. However, two warehouse beetle field strains were significantly more tolerant to both formulations compared to the laboratory strain, but the PI formulation was still more effective than the EC.

P145 PRI Pesticide Product Evaluator: A tool for IPM

*Emily Morse, emily@pesticideresearch.com, Susan Kegley, and Sharon Adams

Pesticide Research Institute, Berkeley, CA

Currently there are no tools readily available that provide comparative information on the hazards pesticide products pose to human and environmental health. To address this data gap, PRI has developed the PRI Pesticide Product Evaluator, an online, LEED-compliant hazard-ranking tool, as well as pest management bulletins emphasizing non-chemical pest control methods. Each product is evaluated using the Hazard Tier ranking system originally developed by the City of San Francisco, with hazard information on acute and chronic toxicity to humans, wildlife and aquatic life. Water contamination potential, a bee-toxic marker and low-toxicity indicators are also provided. Designed for the IPM professional, the tool features customizable pesticide product lists, product reviews and advanced search capabilities. PRI overlays expert judgment on pesticide active ingredient data and information from leading international, federal, and state agencies including: International Agency for Research on Cancer, US EPA, National Institute of Health, the European Union, California Office of Environmental Health Hazard Assessment, and California Dept. of Pesticide Regulation. PRI pest management bulletins utilize this information to present the hazards associated with chemical methods of pest control and enable users to make informed pest management decisions for a variety of common household and landscape pests.

P146 Wyoming IPM for healthy schools and other facilities

John Connett, jconnett@uwyo.edu

University of Wyoming, Laramie, WY

Integrated Pest Management (IPM) is a dynamic process that helps schools to focus more on prevention than remediation. Generally, the step-based process of IPM is the same for any pest problem in any location. IPM strategies emphasize common sense combined with a variety of biological insights including the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment. Biological, cultural, physical, mechanical, and chemical methods are used in site-specific combinations to solve the pest problem. The IPM approach to managing pests in and around schools helps maintain a safe and healthy environment for students and staff and reduces exposure to pests and potentially harmful chemicals. Additionally, teaching IPM to teachers and students can enhance pest prevention in schools. The Wyoming School IPM website http://www.uwyo.edu/ipm is available for anyone seeking solutions to pests in or around facilities. This Website includes links and videos about pest biology and management details. Data sheets, handouts, and recordkeeping forms that can be downloaded and adapted to any facility situation.

P147 Facilitating compliance with a new IPM regulation in Utah's schools

Ryan S. Davis, ryan.davis@usu.edu

Department of Biology, Utah State University, Logan, UT

In 2013, the Utah Health Department Administrative Code R392-200-7(12) was amended, requiring the use of Integrated Pest Management (IPM) in Utah's public, private, and charter schools. However, over 70% of Utah public school districts have had little to no familiarity with IPM and less than 15% have designated IPM Coordinators. Second to the availability of staff, lack of educational resources is the most cited barrier to practicing IPM in Utah's public schools. To help overcome this educational barrier and to facilitate awareness, enforcement of and compliance with R392-200-7(12), Utah State University Extension and the Utah Coalition for IPM in Schools developed eleven workshops that were presented around the state to school personnel and local health officials. Workshop curriculum included modules on the importance of practicing IPM, Utah's school IPM rule, IPM principles and practices, implementing an IPM program in a school setting, and hands-on exercises, including how to think like an IPM Coordinator and a school IPM tour. Local health officials received a specific module on enforcing the IPM rule. The educational programs reached 153 public and charter school key employees spanning 85 job titles and 56 health department employees. In total, 38% of charter schools, 83% of public schools, and 84% of local health departments received IPM training. This poster summarizes Utah's school IPM rule, the developed educational curriculum, and results from pre- and post-workshop iClicker quizzes and post-workshop evaluations.

P148 Using stakeholder interviews for improved IPM adoption

*Deborah J. Young[1], deborah.young@colostate.edu, Susan Tungate[2], and Ryan Davis[3]

[1]Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO; [2]School of Social Work, Colorado State University, Fort Collins, CO; [3]Department of Biology, Utah State University, Logan, UT

In this study, a series of stakeholder interviews were conducted to assess the "readiness" of public school districts to engage with learning about and implementing integrated pest management (IPM). Interviews were evaluated using the Community Readiness (CR) model (Plested, Edwards, and Jumper-Thurman, 2006). The model maps out how communication flows or is impeded, where decisions are made in the school hierarchy, information and training needs, and potential obstacles to IPM implementation. This information was used to tailor the outreach and education approaches offered to school districts. We conducted telephone interviews with (1) key stakeholders (grounds and building maintenance crews, custodial staff, teachers, principals, risk managers, kitchen/nutrition staff, nurses and principals) in five "large" school districts and (2) key stakeholders (facility managers and superintendents) in ten "small" school districts. "Small" and "large" are defined based on the number of students per district. Interview questions and responses were compiled, collated and analyzed by the research team using the CR model. The study assessed each school district along several dimensions, including current efforts, knowledge of these efforts, knowledge about the topic, support of leadership, available resources and school district size. Extension professionals and educators can improve outreach efforts and IPM adoption through a better understanding of culture, opportunities, human health and environmental concerns, and readiness for change.

P149 Stop School Pests: Standardized national school IPM training

Dawn Gouge[1], Lucy Li[1], Shaku Nair[1], Dave Kopec[1], Kai Umeda[1], Lynn Braband [2], Erin Bauer[3], Clyde Ogg[3], Herb Bolton[4], Marcia Duke[5], Carrie Foss[6], Sherry Glick[7], Fudd Graham [8], Janet A. Hurley[9], Kathy Murray[10], Michael Page[11], Susan T. Ratcliffe[12], Gregg Smith[13],Tim Stock[14], Carol Westinghouse[15], Deborah Young[16], *Mariel Snyder, msnyder@ipminstitute.org[17], Kelly Adams[17], Thomas Green[17], and dozens of professionals working in schools who are reviewing and pilot testing modules

[1]University of Arizona; [2]Cornell University; [3]University of Nebraska-Lincoln; [4]USDA-NIFA; [5]National Pest Management Association; [6]Washington State University; [7]U.S. Environmental Protection Agency; [8]Auburn University; [9]Texas A&M University; [10]Maine Department of Agriculture, Conservation and Forestry; [11]Florida Department of Agriculture and Consumer Services; [12]North Central IPM Center; [13]Salt Lake City School District; [14]Oregon State University; [15]Informed Green Solutions, Inc; [16]Colorado Coalition; [17]IPM Institute of North America

The Stop School Pests Training and Certificate Project is designed to increase adoption of IPM in K-12 schools. Implementing a national training and certificate program for school staff will reduce pest and pest management related risks. Our partners and affiliates include professionals from universities, non-governmental organizations, school districts and State and Federal agencies. The objective is to create a sustainable training system to increase the IPM proficiency of pesticide applicators, administrators, facility managers, custodians, teachers, food service staff, maintenance, school nurses and grounds management staff. Our effort includes on-line training as well as in-class teaching materials and proficiency exams, which will be crowd-sourced.

P150 Promoting IPM in affordable housing: A partnership between academia and the community

*Nancy M. Crider[1], nancy.m.crider@uth.tmc.edu, Susannah Reese[2], Dion Lerman[3], and Michael Swoyer[2]

[1]University of Texas Health Science Center Houston, TX; [2]Northeastern IPM Center, Ithaca, NY; [3]Penn State University Philadelphia Outreach Center, Philadelphia, PA

Since 2007, the StopPests program has been bringing IPM to affordable housing across the country. With funding from a US Department of Housing and Urban Development (HUD) and US Department of Agriculture (USDA-NIFA) interagency agreement, the evidenced based program has worked with more than 82 local housing authorities (LHAs) nationwide to provide hands on training. In 2012, the scope expanded to include Property-Based Rental Assistance Properties (PBRA). Qualifying sites work with a StopPests Consultant to implement an IPM program. Housing management picks a pilot site and names a local IPM Coordinator. The IPM coordinator in partnership with the StopPests consultant work to develop the capacity of the pilot site. IPM materials provided by the StopPests program are research-based, offer a balanced and objective approach to pest management in affordable housing and are intended to be used in their entirety. Participating housing providers have the opportunity to host a free, on-site IPM in Multifamily Housing Training.

P151 Quality of life impacts of bed bug (*Cimex lectularius* L.) infestations

Dawn H. Gouge[1], Al Fournier[1], *Shujuan Li[1], LiSj@cals.arizona.edu, Tim Stock[2], Alvaro Romero[3], Deborah Young[4], Shaku Nair[1], Carrie R. Foss[5], Ruth Kerzee[6], Dave Stone[7], and Megan Dunn[8]

[1]University of Arizona, MAC, Maricopa, AZ; [2]Oregon State University, Integrated Plant Protection Center, Corvallis, OR; [3]New Mexico State University, Entomology, Las Cruces, NM; [4]Colorado State University, Plant Sciences, Fort Collins, CO; [5]Washington State University, Puyallup Research and Extension Center, Puyallup, WA; [6]Midwest Pesticide Action, Chicago, IL; [7]National Pesticide Information Center, Oregon State University, Corvallis, OR; [8]Northwest Center for Alternatives to Pesticides, Eugene OR

Living with bed bugs can cause economic, social and human health costs. A coalition of institutions created an online survey to: (1) identify risk factors associated with infestations; (2) document specific stresses attributed to bed bugs; and (3) compare pest management practices. Data were collected from residents in the US who had experienced, were currently experiencing, and had never experienced infestations. First quarter analysis (n=289) indicated that people with lower annual income reported more infestations; 42.3% of residents had pest control experts identify the insects while 38.0% used internet/literature resources; and 16.7% of residents with bite reactions required medical treatment. Results showed 25.7% had changed residence 2-3 times in 5 years, compared to 27.6% with a history of bed bugs, and 17.9% with no history. Residents with no bed bug history stay with friends/family less often, and host visitors less often. Residents with infestations are twice as likely to have acquired second hand articles two or more times per year, compared to residents with a past history of bed bugs. Residents with bed bug experience reported sleep loss (88.5%); 37.5% could not fulfill work duties as well as usual; 16.7% could not care for dependents as well as usual; 63.9% reported financial losses. Those with infestations felt isolated (47.2%) and 26.9% who no longer had bed bugs still felt isolated. Infestations were associated with an increase in alcohol consumption, smoking, prescription and illicit drug use; 26.4% of residents reported a decline in health and 23.5% with bed bugs reported using do-it-yourself treatments with hazardous chemicals.

P152 Tackling fire ants, after a student death, a case study for school IPM in TX

*Janet A. Hurley[1], ja-hurley@tamu.edu, Paul Nester[2], Brett Bostian[3], and Walter "Buster" Terry[3]

[1]Department of Entomology, Texas A&M AgriLife Extension, Dallas, TX; [2]Department of Entomology, Texas A&M AgriLife Extension, Houston, TX; [3]Corpus Christi ISD, Facilities and Operations Department, Corpus Christi, TX

In September 2012, a middle school student died after numerous fire ant stings during a junior high football game in Corpus Christi, TX. Allergic reactions to fire ant stings are rare, but require quick thinking and proactive first aid work. Shortly after this, Texas A&M AgriLife Extension school IPM program team was contacted to assist in reviewing the districts' IPM program, but also review the fire ant management program and make recommendations. The review came in two phases: one to assess the actual school IPM program under the TX Dept of Agriculture's school IPM rules, and the second phase was to review the fire ant management protocols and develop a new treatment protocol for the entire district. Corpus Christi ISD is located on the gulf coast of TX in a semi urban area. The district boasts it covers 63 square miles and has 37 elementary schools, 11 middle schools, 7 high schools, and 3 special campuses, with a total student enrollment of 39,414. To manage this, the district has one IPM Coordinator and 2 pesticide applicators and was using coaches to help with reporting fire ant mounds. After several meetings and revisions to the fire ant management plan for CCISD, the district implemented an improved fire ant management program in spring 2013. The result was they spent less money, have had fewer calls and complaints about fire ants and the coaching staff is now using more land than the 1.5 acres they were using for games.

P153 Cases of 12-year residential home termite IPM in Alabama

Xing Ping Hu, huxingp@auburn.edu

Department of Entomology and Plant Pathology, Auburn University, Auburn, AL

Subterranean termites (Isoptera: Rhinotermitidae) are wood-eaters and may attack and cause serious structural damage to buildings. Termites in nature are to recycle wood and other plant matter, being considerable ecological importance. In urban settings, termites attack buildings with conditions conducive to them, of which wood and moisture are the most attractive. Termites live in colonies, work in groups, and build in- and above-ground networks tunneling towards moisture in search of food-wood. Proper management of building and surrounding can prevent or eliminate termite damage. Ten residential buildings of various structure types and various termite pressures were selected for long-term IPM case study in 2002. Only 3 of the 5 termite-infested buildings were treated with Termidor termiticide. All the buildings have been monitored with baiting stations. Result of the 12-year study involving 10 residential buildings shows that practices that eliminate constant moisture and minimize humidity level helps terminate termite infestations and prevent new termite incidence.

P154 Efficacy of *datura stramonium* extracts incorporated into soil samples on termites' mortality

*Adenike Christy Adeyemo, yemonike@yahoo.com, and Adetayo Seun Aderinlewo

Department of Biology, School of Science, Federal University of Technology, Akure, Ondo State, Nigeria

The use of soil barrier or treatment is exclusion of termites from a building and other structure in ground contact. This study was carried out to determine the anti-termitic activity of (fresh and dried) leaves and seeds of *Datura stramonium* extracts in soil barrier tests against *Coptotermes formosanus* termites at temperature and relative humidity of 28±2°C, 75±5% respectively. Fresh and dried leaf petroleum ether extracts at 40% concentrations were more effective than 30% concentrations. Tunnels were built by the termites at both concentrations on soil treated with both fresh and dried leaf extracts. The mean mortality of termites on soil treated with 30% and 40% concentration of plant extracts were 41.67% and 49.00% respectively. However, the study revealed that seed extracts significantly ($P<0.05$) protected the second food source as termites were unable to cross the treated barriers, therefore *Datura stramonium* extracts are promising botanicals in termite control due to its repellent as well as toxic effects on *Coptotermes formosanus* termites.

P155 Larvicidal evaluation of *Hyptis suaveolens* as lead-agent for control of mosquito-borne microbes

H. Babayi[1], *I.K. Olayemi[2], israelolayemi2013@gmail.com, B.O. Ibrahim[1], and L.A. Fadipe[3]

[1]Department of Microbiology, Federal University of Technology, Minna, Nigeria; [2]Department of Biological Sciences, Federal University of Technology, Minna, Nigeria; [3]Department of Chemistry, Federal University of Technology, Minna, Nigeria

The paucity of sustainable insecticidal lead-agents of public health importance was the reason why this study was carried out to evaluate the potentials of extracts of *Hyptis suaveolens* in vector control of mosquito-borne diseases. Multi-solvent extracts of vegetative parts (i.e., leaves, stems and roots) of *H. suaveolens* were prepared and bio-assayed against 4th instar larvae of *Culex pipiens* mosquitoes, following World Health Organisation's recommended protocols for testing the efficacy of insecticides. The results showed that the vegetative parts of the plant species contained seven phytochemical compounds namely, balsam, carbohydrates, glycosides, saponnins, steroids, tannins and terpenes, though in varied relative concentrations. Larvicidal tests revealed that, irrespective of solvent type, the leaf extracts were most toxic to the mosquitoes, followed by those of the stem while root extracts were the least toxic. The lethal concentrations of the extracts varied considerably both among solvent types within a plant material, as well as, among the vegetative parts. The mean LC_{50} and LC_{90} were respectively 0.35±0.18 and 0.86±0.59 mg/l for leaf extracts, 0.53±0.27 and 0.90±0.51 mg/l for stem extracts, and 1.08±0.79 and 1.90±1.26 mg/l for root extracts. These results indicate that *H. suaveolens* contains bio-active phytochemicals with significant mosquito larvicidal activities; and hence, is a potential veritable source of sustainable lead-agent for reducing the burdens of mosquito-borne diseases.

P156 Great Lakes Vegetable Working Group addressing vegetable industry IPM priorities

*Brad Bergefurd[1], Bergefurd.1@osu.edu, James Jasinski[2], and Great Lakes Vegetable Working Group

[1]Ohio State University Extension, Portsmouth, OH; [2]Ohio State University Extension, Urbana, OH

The Great Lakes Vegetable Working Group (GLVWG) was organized in October 2004 with funding support from the NC IPM Center. Members are researchers and Extension specialists from the departments of Entomology, Horticulture, Plant Pathology, and Weed Science primarily from land grant universities located in IL, IN, KY, MI, MN, NY, OH, Ontario, Canada, PA, and WI. Members are also from vegetable commodity groups, grower associations, and industry representatives from the Great Lakes region. Vegetables are high value crops that are management intensive, with a farm gate value in the Great Lakes region exceeding $1 billion annually. While researchers, specialists, and Extension educators dedicated to vegetable production continue to shrink, the GLVWG consists of a broad community of knowledgeable individuals united by common regional IPM priorities and projects. The GLVWG meets annually to exchange current research and program information that strengthens interstate and international cooperation, and is the mechanism used to identify current priorities affecting the vegetable industry. From the priority list, members vote to decide which issues will be addressed in the upcoming year. A Project Committee is formed to develop strategies to address each issue. Results of the Project Committee are communicated to members and stakeholders via our listserv, website, conference calls, and presentations at local and regional vegetable meetings. Projects have included Corn Earworm Resistance Monitoring Network, vegetable IPM adoption surveys, IPM workshops, creating and publishing a Pest Identification and Management pocket guides and mobile app's and teaching a five-part season extension webinar series.

P157 Addressing the IPM needs of part-time, diverse vegetable producers in Kentucky

*Ric Bessin[1], rbessin@uky.edu, Shubin Saha[2], and Patty Lucas[3]

[1]Department of Entomology, University of Kentucky, Lexington, KY; [2]Department of Horticulture, University of Kentucky, Lexington, KY; [3]University of Kentucky Research & Education Center, Princeton, KY

Local food movements and direct marketing through farmers markets and CSAs has greatly increased the number of part-time producers growing a wide diversity of vegetables. Implementing IPM can be a challenge as these producers are often widely scattered and grow crops on limited acreages that are

not large enough to support private scouting and advisory services. Many of these producers are new to agriculture and farm only part time to supplement income from other sources. We believe that the pest, disease, and disorder recognition and identification are primary constraints to the adoption of IPM programs for these producers. To address this need, color insect, disease, weed, and disorder scouting guides have been printed to assist producers with identification and direct them to appropriate IPM information for 10 commonly grown commodities/crop groups. Two of these scouting guides, Solanaceous crops and Cucurbit crops, have been printed in Spanish. The decision to print these guides rather than produce them as mobile apps was made in order to make these accessible to under-served Amish and Mennonite communities.

P158 Development and implementation of fruiting-vegetable grafting technologies for field production systems in the US

Frank J. Louws, frank_louws@ncsu.edu

NSF-Center for IPM and Department of Plant Pathology, North Carolina State University, Raleigh, NC

A national program was initiated to advance the productivity and profitability of US fruiting vegetable enterprises by integrating grafting technologies into these production systems through stakeholder-driven, systems oriented and trans-disciplinary strategic research, extension and education. Private partners in the project include organic and conventional producers, seed and robotics companies, industry publishers/educators, and research and extension personnel. Growers of fruiting vegetables (tomatoes and melons) face many environmental, technical and market forces that demand innovative solutions to overcome constraints or to expand into emerging markets. For example, much of the fruiting vegetable industry, particularly in the southern production regions, has relied on fumigation as the primary soilborne pest management tactic. Loss of methyl bromide and major fumigant label changes has made fumigant use a much less viable option. Likewise, several pathogens are poorly controlled by fumigants or IPM tactics and growers seek efficient use of water, nutrient, and land resources. In addition, emerging markets include extended season production using high tunnels, organic and specialty cultivars, changing demographics and increased consumer demand for fresh vegetables for health. However, production is constrained due to lack of host resistance to biotic (e.g. disease) or abiotic (e.g. cold soils, high salt content) stressors not readily integrated into customer-preferred fruiting vegetable cultivars. The project advanced the capacity to produce and use grafted plants from the retail store level to large commercial farms to manage soilborne diseases and nematodes, increase tolerance to abiotic stress and increase yield and/or fruit quality. Work continues on opportunities and challenges.

P159 Integrated management of soilborne pathogens of tomato and strawberry: Local solutions and global benefits

Frank J. Louws, frank_louws@ncsu.edu

NSF-Center for IPM and Department of Plant Pathology, North Carolina State University, Raleigh, NC

Multiple soilborne pathogens limit production of tomato and strawberries in NC and surrounding states. A multi-state, interdisciplinary and stakeholder driven research and extension program was implemented to mitigate losses associated with the phase-out of methyl bromide (MeBr) as a soil fumigant due to its ozone depleting properties. Three broad levels of IPM research and extension were implemented in parallel including 1) Tactic Substitution that addressed short term needs of growers who sought non-ozone depleting fumigant alternatives; 2) Tactic Diversification that focused on medium term alternatives that included non-fumigant and IPM based tactics (e.g. rotation, vegetable grafting); and 3) Tactic Development that advanced long-term goals to explore microbial ecology and farming systems-based approaches to replace MeBr-dependent production systems (e.g. anaerobic soil disinfestation; biofumigation; compost- cover crop systems). Significant advancements were made in the science and practice of disease management and crop production. Considerable work was accomplished to identify the presence, diversity and dynamics of the soilborne pathogens associated with root and crown rot problems. Advances were accomplished through Phase I trials to evaluate new products or methods of disease management, and Phase II (small scale) or Phase III (large scale) on farm tests. On-farm work was often designed as randomized complete block design experiments with 3-4 replications and many data sets were collected by growers. All growers in the region transitioned away from MeBr and this local effort contributed to the overall decline in measurable stratospheric bromine levels and apparent increase in ozone levels in the upper stratosphere (global benefits).

P160 Utilizing pest phenology to manage cabbage maggot in Brassicas

Shimat V. Joseph, svjoseph@ucanr.edu

University of California Cooperative Extension, Salinas, CA

Cabbage maggot [*Delia radicum* L.] is a serious pest of Brassicas in the central coast of California. Feeding injury from *D. radicum* maggots could cause serious economic losses. *D. radicum* has been managed using chlorpyrifos insecticide applied at planting but currently, the use of chlorpyrifos is heavily regulated. Alternatively, other insecticides including reduced-risk insecticides available for *D. radicum* management are also used. Research showed that incidence of *D. radicum* infestation on seeded-Brassica increased a month after planting. Studies also suggested that reduced-risk insecticides,

spinetoram, cyantraniliprole, and clothianidin have reasonable activity against *D. radicum* maggot. Two experiments were conducted to determine the utility of *D. radicum* phenology on its management in Brassica. In the first experiment, recommended rates of spinetoram, cyantraniliprole, and clothianidin were applied to transplant plugs and were compared with delayed spray of same insecticides three weeks after transplant. In the second experiment, chlorpyrifos was applied as spray at planting of turnip seeds and was compared with a delayed spray application two weeks after planting. Results from first experiment suggest that *D. radicum* infestation was significantly lower in both at-transplant and delayed spray application of clothianidin than in untreated check. However, only the at-transplant application of spinetoram, and cyantraniliprole significantly suppressed *D. radicum*. The second experiment showed that delayed application of chlorpyrifos significantly suppressed *D. radicum* over at-plant application. These experiments suggest that application of insecticides relative to *D. radicum* phenology in Brassica would provide a degree of *D. radicum* suppression.

P161 Development and impact of a pest alert system for potato growers in the Columbia Basin of Washington

*Carrie H. Wohleb, cwohleb@wsu.edu

Washington State University Extension, Moses Lake, WA

WSU Extension has operated an insect sampling network in the Columbia Basin of Washington since 2009 to monitor pest populations and report information about their size and location to potato growers. The sampling network began by targeting aphids, beet leafhoppers, and potato tuberworms. Potato psyllid monitoring was added in 2012 following a major outbreak of zebra chip disease, which is spread by this insect. Each year 40 potato fields are monitored for insects. Results are posted weekly to the "Potatoes at WSU website". In 2010, emailed alerts were added as a better way to communicate with potato growers. The alerts summarize sampling results and recommendations for pest management, and include maps showing weekly predictions of pest densities throughout the region. The maps are generated using GIS technology and models that were validated for each targeted pest. There are currently more than 600 subscribers to Potato Pest Alerts, including most potato producers in the region. When asked in a survey why they subscribe, most reported that they like to see regional monitoring data (93%). Many noted that information about where and when pests are showing up helps them know what to look for in their own fields. Respondents also indicated that they read the alerts for information about new pests and diseases (82%), late blight information (72%), pest management advice (50%), and help on insect scouting (49%). All respondents agreed that Potato Pest Alerts help minimize pest outbreaks by providing timely information that can be acted on before pests become established.

P162 Companion and refuge plants to enhance control of insect pests in vegetables

*Jesusa C. Legaspi, Jesusa.Legaspi@ars.usda.gov, and Neil W. Miller

USDA-ARS, Center for Medical, Agricultural, and Veterinary Entomology / Florida A&M University-Center for Biological Control, Tallahassee, FL

Whiteflies and aphids are important insect pests in vegetable crops. To mitigate the use of chemical insecticides, "push-pull" strategies can be used as components of sustainable or cultural pest management. We conducted laboratory olfactometer or odor detecting tests to measure the effects of arugula (*Eruca sativa* cv. Nemat), and 2 mustard variety plants, *Brassica juncea* cv. Caliente 19 and giant red mustard, as whitefly repellents. Preliminary results showed that mustard and arugula plants are promising repellent plants against the sweetpotato whitefly, *Bemisia tabaci*, comprising a potential "push" component. Preliminary analysis of a field study on annual ornamental plants, sweet alyssum, *Lobularia maritima*, intercropped with kale revealed the most abundant predatory hoverflies to be *Toxomerus marginatus*, followed by *Allograpta oblique*, *Eupeodes americanus*, *Ocyptamus fuscipennis*, *Toxomerus geminatus*, *Toxomerus boscii*, and *Pseudodoros clavata*. Hoverflies are important generalist predators of aphids such as the green peach aphid, *Myzus persicae*. "Push-pull" strategies can be complemented with natural enemy refuges as cultural management techniques in farmscaping towards sustainable management of whiteflies and aphids.

P163 Evaluating pesticide effects on pollinators and disease efficacy in cucurbits

*James Jasinski[1], jasinski.4@osu.edu, Reed Johnson[2], and Thomas Janini[3]

[1]Department of Extension, The Ohio State University, Urbana, OH; [2]Department of Entomology, The Ohio State University, Wooster, OH; [3]Agricultural Technology Institute, The Ohio State University, Wooster, OH

Honey bees (*Apis mellifera*) and native squash bees (*Peponapis pruinosa*) are known pollinators of cucurbit crops and are therefore subjected to pesticides used in conventional production practices. To determine the effects of various pesticides and combinations of pesticides on these bees, a series of LD50 tests with Bravo, Rally, Pristine, Quintec, carbaryl, and bifenthrin were performed using topical applications to the thorax and then observing survival and behavior 24 hours later. Neither squash bees nor honey bees become more susceptible to the insecticide bifenthrin when exposed to field-relevant concentrations of thiamethoxam. Squash bees demonstrated a remarkable tolerance for carbaryl when compared to honey bees. The addition of fungicides to carbaryl did not greatly

impact mortality, but the combination of bifenthrin with Rally was approximately 3-times more toxic to honey bees than bifenthrin alone. Fungicides used in the bioassay were also applied to pumpkin and squash plots to evaluate powdery mildew efficacy of "bee friendly" and conventional fungicide programs. One "bee friendly" fungicide program alternating Quintec plus Manzate Pro Stick with Regalia plus sulfur, and one conventional program of Torino plus Bravo alternated with Rally plus Bravo had numerically lower powdery mildew leaf ratings and acceptable efficacy compared to other treatments in the study for the majority of the season.

P164 Beneficial insects in sweet corn bordered by native perennial and pasture border rows

John D. Sedlacek, *Karen L. Friley, karen.friley@kysu.edu, and Lindsey Morris

College of Agriculture, Food Science and Sustainable Systems, Kentucky State University, Frankfort, KY

Prior to European settlement, native perennial plants indigenous to the United States were abundant covering entire regions of Kentucky and bordering states. Native perennials are important for ecosystem and environmental health. These plants provide habitat for wildlife including beneficial insects otherwise known as natural enemies. It has been demonstrated that non-crop plants such as some weeds and native perennial grasses and flowering plants planted near crop borders can enhance populations of natural enemies. Therefore, the objective of this research was to identify and quantify beneficial insects in native perennial and pasture border rows and compare their numbers in each habitat. This research was conducted on the Kentucky State University Research and Demonstration Farm in Franklin County, Ky. Sticky traps 15 cm x 15 cm were set in sweet corn and native perennial and pasture border rows to compare diversity and abundance of insects. Native perennial border rows contained 16 species of plants. There were five grasses and eleven species of flowering plants. Pasture borders were a mixture of grasses and broad leaf weeds. Traps were collected and analyzed for 12 weeks. Insects were identified to family and species when possible. Big eyed bugs (*Geocoris* sp.), syrphid flies (Syrphidae), lady beetles (Coccinellidae), green lacewings (*Chrysoperla* sp.), and minute pirate bugs (*Orius insidiosus*) were the most abundant insects caught. Results indicate that this research should continue for one more growing season to determine if age and maturity of the border plots influence beneficial insect numbers.

P165 Trap cropping: A simple and effective organic IPM approach to manage multiple pests in cucurbits

*Jaime C. Piñero, pineroj@lincolnu.edu, and Jacob T. Wilson

Lincoln University Cooperative Research and Extension, Jefferson City, MO

Trap cropping functions by delivering pest-behavior-modifying stimuli that attract the pest to the border areas thereby reducing pest numbers resulting in reduced or no need for insecticide application to the main crop. For a 4-year period (2011-2014), the Lincoln University (LU) IPM Program conducted research aimed at assessing, using a comparative behavioral approach, the attractiveness of Blue Hubbard, Red Kuri Hubbard, and Buttercup squash (trap crop plants) to adult spotted (*Diabrotica undecimpunctata howardii*) and striped cucumber beetle (A*calymma vittatum*), and squash bug (*Anasa tristis*). These insects have consistently been identified as the most damaging insect pests of cucurbits in areas of the US where the crops are grown. In addition, the ability of trap crop plants to prevent insect pest populations from exceeding economic thresholds in the cash crops was assessed on each year. Results indicate that all three squash varieties suppressed squash bugs from cash crops, but for spotted and striped cucumber beetles Red Kuri squash and Blue Hubbard squash performed best throughout the growing season. Seven farmer cooperators, including a North Central Region Sustainable Agriculture Research and Education (SARE) Farmer and Rancher grant recipient, have adopted the trap cropping approach in their vegetable farms. Four of these farms are certified organic. For one farmer that now practices IPM, use of trap cropping has saved him about $900 per hectare in labor, pesticide, and fuel, per growing season. Our findings indicate that Red Kuri Hubbard and Blue Hubbard squash are excellent trap crop plants to manage key insect pests of cucurbits in organic systems.

P166 Effect of organic fertilizers and PGPR on the population growth of *Aphis gossypii* in the cucumber greenhouse

Parvin Hosseini, *Jabraeil Razmjou, razmjou@uma.ac.ir, Gadir Nouri Ganbalani, Seyed Ali Asghar Fathi, and Babak Sardari

Department of Plant Protection, Faculty of Agricultural Science, University of Mohaghegh Ardabili, Iran

The melon aphid, *Aphis gossypii* Glover, is an important pest of cucumbers specially in the greenhouses. In this research, the effects of PGPR, Vermicompost, Humic and Nitrogenous fertilizers on population growth of *A. gossypii* and life table parameters were investigated. The plants were grown in a greenhouse at 25±3 C , 65±5% RH and a photoperiod of 16 L: 8 D hours. The results indicated that there were significant differences among treatments on the duration of nymphal stage, reproduction and the longevity of the adults. Also significant differences were observed among the treatments with respect to R0, rm, λ, DT and T parameters. The highest rate of rm was observed on Control treatment (0.388 female/female/day) whereas the lowest values of rm was found in the

combination of Vermicompost and Humic treatment (0.315 female/female/day). The highest (113.94 nymphs/female/generation) and lowest (19.09 nymphs/female/generation) (R0) were observed on Nitrogen treatment and in the combination of Vermicompost-Humic fertilizers. Our findings indicate that the combination of Vermicompost and Humic fertilizers can be useful in the IPM of *A. gossypii* in the cucumber greenhouses by reducing the population growth of this aphid.

P167 IPM of insect pests of vegetable crops in the Holland Marsh, Ontario

*Dennis Van Dyk, vandykd@uoguelph.ca, and Mary Ruth McDonald

Department of Plant Agriculture, University of Guelph, Guelph, ON, Canada

An IPM program is provided to vegetable growers in the Holland/Bradford Marsh, Ontario, by the University of Guelph Muck Crops Research Station. In 2014, 79 vegetable fields (onion 378 A, carrot 405 A, and celery 60 A), were scouted for 27 growers. The emergence of common carrot, onion, and celery insect pests were forecasted using degree day models and monitored in field using various traps. Carrot weevil adults were first found in wooden traps on 20 May. This was at 124 DD (base 7C) and consistent with the forecast of egg deposition beginning at 147 DD. Carrot rust flies were first found on sticky traps on 29 May at 454 DD (base 3C), 3 days after the maximum DD for emergence (395). The spray threshold (0.1 flies/trap/day) was reached the second week of June. However, rust flies were present from most of July and August and there was no clear break between first and second generations. Onion maggot adults were first found on sticky traps on 15 May, at 201 DD (base 4C), very close to the 210 DD emergence threshold. Onion thrips were first found in onion plants on 23 June. Only one field reached the 1 thrips/leaf spray threshold in mid-July while a few more fields reached threshold in early August. The first aster leafhopper was observed on 29 May, at 146 DD (base 9) within 2 days of the emergence threshold of 128 DD. Day degree forecasts were accurate for all insect pests except carrot rust flies.

P168 Assessing the risk of spotted wing drosophila (SWD), *Drosophila suzukii*, infestation to tomatoes

*Marion E. Zuefle[1], mez4@cornell.edu, and Gregory Loeb[2]

[1]NYS IPM, Cornell University, Geneva, NY; [2]Department of Entomology, Cornell University, Geneva, NY

Spotted wing drosophila (SWD), *Drosophila suzukii*, an invasive fruit fly originally from Asia, appeared in NY in 2011 and has become of major concern to small fruit growers. Unlike other fruit flies, it has a serrated ovipositor that allows it to penetrate intact fruit and lay eggs just prior to harvest. The larvae will hatch and develop within the fruit with no initial external damage to the fruit. Current pesticide control measures target the adult but there is great risk of developing resistance. Known hosts of SWD include soft skinned fruit like raspberries, blueberries, and strawberries. Even though the wild host range of SWD includes nightshades (*Solanum* spp.) the expansion of spotted wing drosophila onto other soft skinned fruit or vegetables is still unknown and no research has been conducted to evaluate the threat of SWD to tomatoes, *Solanum lycopersicum*, a major crop in NY. Fifteen tomato varieties were used to determine the likelihood of SWD to lay eggs in tomatoes in the field as well as in the lab. The penetration force or skin firmness for all varieties was determined and compared to known hosts of SWD. No SWD emerged from any intact tomatoes collected from the field. Four percent of cracked tomatoes collected from the field had SWD emerge. When SWD adults were placed on intact tomatoes in the lab under a no choice situation 12% of the tomatoes had some SWD emerge. There was a slight correlation between skin firmness and SWD emergence (both intact and cracked).

P169 Ground dwelling insects in sweet corn bordered by native perennial and pasture border rows

*Karen L. Friley, karen.friley@kysu.edu, John D. Sedlacek, and Denita Brown

College of Agriculture, Food Science and Sustainable Systems, Kentucky State University, Frankfort, KY

This research was conducted on the Kentucky State University Research and Demonstration Farm in Franklin County, KY. Pitfall traps were set in sweet corn and native perennial and pasture border rows to compare ground dwelling insects and spiders in each of the habitats. The native perennial border rows contained 16 species of plants including big bluestem (*Andropogon gerardii*), thimbleweed (*Anemone virginiana*), New England aster (*Aster novea-anglica*), side-oats Grama (*Bouteloua curtipendula*), purple coneflower (*Echinacea purpurea*), gray-headed coneflower (*Ratibida pinnata*), rattlesnake master (*Eryngium yuccifolium*), common boneset (*Eupatorium perfoliatum*), blue lobelia (*Lobelia siphilitica*), bee balm (*Monarda fistulosa*), switchgrass (*Panicum virgatum*), foxglove beardtongue (*Penstemon digitalis*), hairy beardtongue (*Penstemon hirsutus*), slender mountain mint (*Pycantheum tennuifolium*), little bluestem (*Schizacharium scoparium*) and prairie dropseed (*Sporobolus heterolepis*). Pasture border rows were a mixture of johnsongrass (*Sorghum halepense*), foxtail (*Setaria faberi*), fescue (*Festuca arundinacea*), orchard grass (*Dactylis glomerata*), and pigweed (*Amaranthus retroflexus*). Two pitfall traps were deployed in each border row 25 m long X 2 m wide. Two traps were set equidistant from the edges and each other in the interior of the 25 m X 12 m sweet corn plots. The traps were collected and analyzed for 10 weeks. Ten groups of insects were identified and quantified. They were ground beetles, rove beetles, total Coleoptera, ants, total Hymenoptera, Orthoptera, Hemiptera, Diptera, green lacewings, and brown lacewings. Average number of ground dwelling insects will be presented

for each of the four habitat types. Ground beetles, total Coleoptera, ants and total Hymenoptera were the largest groups of insects caught.

PI70 Measuring the impact of IPM activities on tomatoes in East Africa

*Jackline Bonabana-Wabbi[1], jbonabana@caes.mak.ac.ug, Dan B. Taylor[2], George W. Norton[2], Margaret Mangheni[1], Jenina Karungi[1], Peter Sseruwagi[3], Ruth Amata[4], Monica Waiganjo[4], Jesca Mbaka[4], Amon Maerere[5], Samuel Kyamanywa[1], Mark Erbaugh[6], Sally Miller[6], and Julian Kirinya[1]

[1]Department of Agribusiness and Natural Resource Economics, Kampala, Uganda; [2]Department of Agricultural and Applied Economics, Virginia Tech, Blacksburg, VA; [3]Mikocheni Institute of Agricultural Research, Dar es Salaam, Tanzania; [4]Kenya Agricultural Research Institute, Nairobi, Kenya; [5]Sokoine University of Agriculture, Morogoro, Tanzania; [6]Ohio State University, Columbus, OH

Economic surplus modeling was used to estimate benefits of adoption of six IPM technologies on tomato- an important horticultural crop in Uganda, Kenya and Tanzania. Results indicate that IPM adoption results in yield increases ranging from 54% to 268% depending on the implemented technology. In addition, postharvest treatment of tomatoes with sodium hypochloride resulted in a 35% reduction in yield loss (from the current 50% postharvest loss) thereby increasing the shelf-life and hence marketable surplus of tomatoes. IPM technologies also reduce costs ranging from 70% (in the case of grafting and high tunnels in Kenya) to about 6% (mulching in Uganda). The study shows that the internal rates of return for all the six technologies considered exceeded the market interest rate implying that all were worthwhile interventions with positive net present values that ranged from $820,000 to $29.5 million. Summing over the six interventions, the aggregate undiscounted impacts each computed over a 20-year period amount to $526 million achievable between 2000 and 2030. Policy interventions that foster the development and adoption of IPM technologies in the East African region will improve food and nutritional security, increase household incomes and uplift the livelihoods of smallholder farmers.

PI71 South American tomato moth (*Tuta absoluta* Meyr) in Ukraine

Natalija Skrypnyk, natalija.skripnik@yandex.ua

Department of Plant Quarantine, Institute of Plant Protection of the NAAS, Ukraine

In Ukraine the problem of invasive species is getting worse every year. South American tomato moth (*Tuta absoluta* Meyr) is one of the dangerous quarantine organisms. Information presented has been confirmed by the results of monitoring. South American tomato moth, also known as the tomato leafminer, is a new threat to the Ukraine and is considered to be more dangerous than the Colorado potato beetle. With this pest we have observed a high rate of reproduction (capable of producing up to 10-12 generations per year) and increased activity and adaptation. Over the past decade this pest has actively spread in Europe. *Tuta absoluta* was detected in our country in 2010 in Crimea and the Odessa region. This pest has spread in Kherson, Odessa, Mykolaiv regions, and also in Crimea. The pest-infested area is 194 ha. This pest can create significant problems for production tomatoes and potatoes in Ukraine including reduced yields and quality. Thus scientists' attention should be concentrated on restricting introductions and spread of dangerous invasive species in Ukraine and all over the world.

PI72 Field evaluation of commercial tomato cultivars against ageratum yellow vein virus in Guam

Sheeka Jo A. Tareyama[1], Karl A. Schlub[1], *Robert L. Schlub[1], rlschlub@gmail, and Kai-Shu Ling[2]

[1]Cooperative Extension Service, University of Guam, Mangilao, GU; [2]USDA-ARS, US Vegetable Laboratory, Charleston, SC

In the spring of 2011, a new outbreak of disease with severe leaf curling and stunting was observed in fields of Guam's main tomato variety 'Season Red'. Previous study identified the causal agent as a novel genotype of whitefly transmitted begomovirus, with 90% sequence identity to Ageratum yellow vein virus (AYVV). By 2013, AYVV was causing farmers to cut back production or to abandon tomato production altogether. During Guam's wet-season, August 2014, farm trials were begun to compare 17 commercial tomato varieties for virus resistance and production suitability against the control variety 'Season Red'. Varieties were grape, cherry, elongate, globe, plum, roma, oval, or round, and either determinate or indeterminate. Tomato varieties were compared against the control and analyzed using a cumulative logit model. Virus severity was a natural ordinal response variable. Variety ID vs. Control was an explanatory where each variety was compared against the control variety. Plot ID was added into the model as a blocking factor to improve the model's fit. Partial analysis of the data identified 12 varieties with virus resistance superior to 'Season Red' and five with inferior resistance. Based on Real-Time PCR of pooled samples, AYVV was detected in one superior variety and four of the inferior ones. When symptomless tomatoes were tested, only one of the 18 varieties were positive for AYVV. Five varieties with grape, cherry, globe, or oval fruit types were deemed suitable for Guam, based on their strong virus resistance, high yield and low levels of cracked and unmarketable fruits.

P173 Basket of options for IPM of tomato virus diseases

*Jeninah Karungi[1], jkarungi@caes.mak.ac.ug, Samuel Ahabwe[1], Herbert Jurua[1], Chris T. Muwanika[1], M.K.N. Ochwo-ssemakula[1], Peter Sseruwagi[2], Samuel Kyamanywa[1], and Mark Erbaugh[3]

[1]College of Agricultural and Environmental Sciences, Makerere University, Kampala, Uganda; [2]Mikocheni Agricultural Research Institute, Dar es Salaam, Tanzania; [3]Ohio State University, International Programs in Agriculture, Columbus, OH

Tomato production in Uganda is constrained by low quality planting materials, non-availability of inputs, sub-optimum agronomic practices, pests and diseases. Studies have shown that viral diseases, which mainly occur as sole or mixed infections of tomato mosaic virus, cucumber mosaic virus, and tobacco mosaic virus have quickly become a great threat to tomato production in Uganda. The viruses are mainly spread through use of infected seed and insect vectors. Efforts to manage the virus diseases have been directed at developing options that can be used solely or together to lower occurrence and severity of the vectors and/or diseases. Use of clean seed and insect proof nursery protection, row covers, improved germplasm, and organic soil fertility amendments have been found to offer variable levels of protection at research stations and are ready for validation on farms.

P174 Antagonistic activity of rhizobacteria against bacterial wilt of tomato plants in the Caribbean

Augustus Thomas and *Saravanakumar Duraisamy, duraisamy.saravanakumar@sta.uwi.edu

Department of Food Production, Faculty of Food and Agriculture, The University of the West Indies, St. Augustine, Trinidad

Bacterial wilt is studied as a serious disease in tomato cultivation causing severe yield losses particularly in tropical agriculture. The disease is caused by the soil borne pathogen, *Ralstonia solanacearum* and it is known to infect other crops like potato, banana, egg plant and ginger. Considering the concerns over the use of chemical pesticides to control plant diseases, the current study was carried out to develop an alternative method for the management of the wilt disease in tomato. In this context, a total of 62 rhizobacterial strains were isolated from the different agro-ecosystems of Trinidad. Similarly, the wilt pathogen *R. solanacearum* was isolated from diseased tomato plants in the Toco and Waller-Field areas within the Republic of Trinidad and Tobago and cultured on nutrient agar. The virulence of the pathogen was confirmed using Tetrazolium Chloride Agar, after which, the pathogen was stored in sterile distilled water at room temperature for use in screening techniques. All the rhizobacterial strains have been screened for their antagonistic activity against *R. solanacearum* using two different techniques; the filter paper disc method and the streak method. Out of 62 strains, nine rhizobacterial strains coded ML10, ML13, SAG3, SAG11, SAG19, SAG2, SAG6, TF2 and OG2 showed greater inhibition to the wilt pathogen under in vitro. The preliminary studies showed the greater antagonistic activity of the rhizobacteria against *R. solanacearum* and revealed the potential for developing those rhizobacterial strains as biocontrol agents against bacterial wilt in tomato plants grown in the Caribbean region.

P175 Using loess sulfur mixture for management of powdery mildew diseases in organic farming in Korea

*C. K. Shim, ckshim@korea.kr, M. J. Kim, Y. K. Kim, S. J. Hong, J. H. Park, E. J. Han, and S. C. Kim

Organic Agricultural Division, National Academy of Agricultural Science, Rural Development of Administration, Wanju-gun, Rep. of Korea

One of the techniques for the management of foliar disease of organic farming practice is the use of loess sulfur mixture made with sulfur powder and sodium hydroxide using exothermic reaction. In this study, the effect of water soluble sulfur and the loess sulfur mixture were investigated against powdery mildew in organically cultivated crops of cucumber, squash, hot-pepper, tomato, lettuce and Chinese cabbage. Experiments were carried out with concentration and application period using foliar sprays with high-pressure sprayer in greenhouse and farming practice. The effect of loess sulfur mixture with concentrations of 0, 500, 1,000 and 2,000 ppm (v/v) on the percentage of infested leaf area of powdery mildew was evaluated. The results indicated that all concentrations of loess sulfur mixture had dramatically suppressed powdery mildew caused by *Leveillula taurica* and *Sphaerotheca fusca* in laboratory conditions. Similarly, on suppressive effect for powdery mildew on the six crops, results revealed that with concentrations of 500 and 1,000 ppm of loess sulfur mixture, disease incidence rate was 20.1% and control effect was on average 92.5% in organic farming practice.

P176 Improving carrot insect monitoring methods in the Holland Marsh, Ontario

*Dennis Van Dyk[1], vandykd@uoguelph.ca, Suzanne Blatt[2], Cynthia Scott-Dupree[3], and Mary Ruth McDonald[1]

[1]Department of Plant Agriculture, University of Guelph, Guelph, ON, Canada; [2]Agriculture and Agri-Food Canada, Kentville, NS, Canada; [3]School of Environmental Sciences, University of Guelph, Guelph, ON, Canada

Carrot rust fly (CRF) (*Psila rosae* F.) and carrot weevil (CW) (*Listronotus oregonensis* (Le Conte)) are serious pests of carrots and can cause high levels of damage despite multiple insecticide

sprays and monitoring. A Muck Crops IPM program operates in the Holland Marsh, Ontario, and provides degree day forecasting insect activity information twice a week to growers. Growers' fields are scouted twice per week to provide weevil trap counts and the number of rust flies/trap/day. In 2014 trapping methods were compared to validate and/or improve the current methods for monitoring carrot insects. A comparison was made of yellow and orange sticky traps and traps on an angle. Yellow sticky traps caught more CRF than the orange traps. Sticky traps that were perpendicular to the ground caught more CRF than similar traps at a 45° angle to the ground. Two transects of five CRF traps spaced 50m apart were placed in fields. Traps closer to edges of the field did not catch more carrot rust flies than traps farther into the field. There was no difference found between current practices of placing rust fly traps at the edges of the field compared to traps within the field. Carrot weevil traps were placed in areas with different vegetation surrounding the field. No differences in carrot weevil counts were found between vegetation types while counts varied greatly among fields. These trials will be repeated in 2015 with emphasis on determining the most attractive trap colour for carrot rust fly monitoring.

P177 Development of diseases on muck vegetable crops in the Holland Marsh, Ontario in 2014

*Mary Ruth McDonald, mrmcdona@uoguelph.ca, and Dennis Van Dyk

Department of Plant Agriculture, University of Guelph, Guelph, ON, Canada

The Muck Crops Research Station provides an IPM program to vegetable growers in the Holland/Bradford Marsh region of Ontario, Canada. Fields are scouted twice a week, and growers receive field- specific information on disease and insect presence and also comprehensive IPM updates and forecasts twice a week. The disease forecasting models used are BOTCAST (botrytis leaf blight on onions, *Botrytis squamosa*), DOWNCAST (onion downy mildew), and BREMCAST (lettuce downy mildew, *Peronospora destructor*). In 2014, 79 commercial vegetable fields were scouted for 27 growers. Weather conditions in the 2014 growing season were favourable for many common pathogens of vegetable crops, with above average rainfall and average or below average temperatures for most of the season. DOWNCAST indicated the first sporulation-infection periods in late July and the first sporulation of *P. destructor* was observed on 14 Aug., which is consistent with the 10–15 day latent period. By 21 Aug., 40% of onion fields had symptoms. The spray threshold for BOTCAST occurred on 1 Aug., and disease severity remained relatively low. Stemphylium leaf blight (caused by *Stemphylium vesicarium*) continued to increase and may have masked symptoms of *B. squamosa*. BREMCAST indicated low risk of lettuce downy mildew until mid-July. Cavity spot and pythium root dieback (*Pythium* spp.) were found in all surveyed carrot fields with incidence of 5-45% and 1-15% respectively. Crater rot (*Rhizoctonia* spp.) was found in 89% of fields, with incidence up to 17%. Allium white rot (*Sclerotium cepivorum*) was a major concern with losses of 50-75% in some fields.

P178 Control effect of coffee bark compost against soil borne disease in organic ginger in Korea

*M. J. Kim, kjs0308@korea.kr, C. K. Shim, Y. K. Kim, S. J. Hong, J. H. Park, E. J. Han, and S. C. Kim

Organic Agricultural Division, National Academy of Agricultural Science, Rural Development of Administration, Wanju-gun, Republic of Korea

Ginger is widely cultivated as a spice material not only in Korea but also in China, Indonesia, Thailand and Japan. This study was aimed to control ginger wilt caused by *Pythium myriotylum* and rhizome rot caused by *Ralstonia solanacearum* with composted coffee bark and manure in organic ginger farming. We treated the N-P2O5-K2O ratio as 30: 20: 10kg / 10a according to the standard method of fertilizer application for ginger cultivation and added dolomite (200kg / 10a) in the untreated control. Treatments were one year old composting coffee bark (400kg/10a), cattle manure (1,000kg/10a), and dolomite (200kg/10a). Ginger root disease onset and growth were investigated from late June to early October in 2014. In the untreated control, the pathogenic bacteria were isolated from the rotten rhizomes of ginger which were collected from organic farms of Seosan in Korea. Twenty-five isolates were divided into fifteen of *Erwinia* sp. and ten isolates of *Ralstonia* sp. on the basis of semiselective media and TTC. Ginger rhizome rot in the coffee compost treatment occurred one month later and at an even lower incidence than conventional ginger practice. In addition, the pathogenic bacterial density of the coffee bark compost treatment was 100 times lower than the untreated control as determined by using semiselective media and TTC.

P179 Efficacy of plant inducers and biopesticides for management of downy mildew on basil

Richard N. Raid, rnraid@ufl.edu

Department of Plant Pathology, University of Florida, Everglades Research and Education Center, Belle Glade, FL

Incited by *Peronospora belbahrii*, basil downy mildew (BDM) has had a devastating impact on basil production worldwide. A field trial was conducted to assess the efficacy of three systemic acquired resistance (SAR) plant inducers alone and in combination with several biopesticides for control of BDM. The experiment was arranged as a split-plot design with variety (susceptible vs tolerant) as the main effect, with four replications of 12 foliar treatments arranged in a randomized complete block design. Foliar treatments were initiated one day after transplants were placed in the ground, planted in

double rows on plastic covered raised beds formed on 2-m centers . Inoculum for the trial relied on natural airborne sources originating from nearby production fields and disease pressure was considered severe, given environmental conditions conducive for BDM. Variety had a significant influence in delaying basil mildew onset, but by the end of the trial, BDM was severe on both the resistant and tolerant varieties. Foliar applications of SAR compounds provided low levels of downy mildew suppression, with biopesticide combinations further reducing mildew severities. However, no combinations provided control sufficient for the production of a marketable crop. These results illustrate the difficulties currently faced by organic basil growers.

P180 Drivers of IPM for onion thrips and iris yellow spot virus in onion

*Diane G. Alston[1], diane.alston@usu.edu, Claudia Nischwitz[1], Daniel Drost[2], Jennifer Reeve[2], and Corey Ransom[2]

[1]Department of Biology, Utah State University, Logan, UT; [2]Department of Plants, Soils, and Climate, Utah State University, Logan, UT

Onion (*Allium cepa* L.) is attacked by a complex of pests: onion thrips (*Thrips tabaci* Lindeman) and the Tospovirus, Iris yellow spot virus (IYSV), are the most economically important in North America. Overuse of insecticides to suppress thrips, the vector of IYSV, has led to insecticide resistance. Our research has identified drivers of interactions among the onion crop and key pests in Utah farmscapes: crop rotation, nitrogen (N) fertilizer rate, soil quality, number and modes of action of insecticide applications, alternate thrips hosts, including nearby crops and weeds, volunteer onions, and cull piles. Random Forest Analysis found significant predictors of high IYVS incidence in onion fields with high thrips densities, low number of insecticide applications, high N in onion leaves, and low inorganic soil N. High thrips densities were associated with high onion leaf N, low inorganic soil N, and low soil dehydrogenase, an indicator of microbial activity. Common crops and weeds in the onion farmscape that harbored onion thrips and IYSV and can serve as green-bridge hosts between growing seasons were alfalfa, common mallow, field bindweed, flixweed, prickly lettuce, and shepherd's purse. A systems-based IPM approach for onion thrips and IYSV is critical to the development of sustainable practices with less reliance on insecticides.

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Note: *Numbers preceded by a "P" indicate a poster; other numbers refer to oral sessions.*

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