IWGO

International Working Group on Ostrinia and other maize pests

29th IWGO Conference

28th to 30th of October 2025

Tan Sri Yusof Hashim Hall MARDI Malaysia

The International Working Group and other Maize Pests (IWGO) is a Working Group of the International Organization of Biological Control – Global (IOBC - Global)

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Stefan TOEPFER, CABI, Hodmezovasarhely, Hungary
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IWGO-IOBC Programme Booklet

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SCIENTIFIC PROGRAMME*

29th IWGO Conference

*Please note that only the name of the presenting author is provided in the IOBC Global IWGO scientific programme

SCIENTIFIC PROGRAMME

Monday, 27 October 2025

17:00 ***Registration, Baba Bar, Palm Garden Hotel***

19:00 ***Welcome Reception, Baba Bar, Palm Garden Hotel***

Tuesday, 28 October 2025

07:45 ***Bus Transfer from Palm Garden Hotel to MARDI Auditorium in Serdang***

08:15 ***Registration & Drop-off Point Posters, MARDI Auditorium***

08:45 ***Welcome Addresses – MARDI Auditorium***

- *Welcome Address, Director General MARDI, YBhg. Dato' Dr. Haji Mohamad Zabawi Abdul Ghani*
- *Welcome Address, IWGO-IOBC-Global Convenor, Dr Ulli Kuhlmann*
- *Group Photo*

09:20 ***Scientific Session 1***

Scientific Session 1: ***Recent research and extension efforts in North America to delay Bt resistance in maize pests***

Session Organizers: Dominic Reisig, North Carolina State University, Plymouth, NC, USA

09:20	Dominic Reisig	Introduction
09:30	Dominic Reisig	Safeguarding *Bt* maize and cotton with experimental social science evidence
09:50	Jocelyn Smith	Resurgence of European corn borer in Canada
10:10	David Kerns	Evolution of southwestern corn borer, *Diatraea grandiosella*, resistance to plant incorporated *Bacillus thuringiensis* proteins in maize
10:30	Tatum Dwyer	Managing a billion-dollar bug: *Bt* resistance of European corn borer in Minnesota and Wisconsin (U.S.)

10:50 ***Coffee/Tea Break***

11:20 *Scientific Session 1 (continued)*

Scientific Session 1: *Recent research and extension efforts in North America to delay Bt resistance in maize pests (continued)*

Session Organizers: Dominic Reisig, North Carolina State University, Plymouth, NC, USA

11:20	Michael Caprio	Corn rootworm resistance management in the presence of crop rotation and seed-blends
11:50	Guoping Li	Commercial strategy of transgenic insect-resistant maize in China
12:10	Christian Krupke	What can the first 20 years of *Bt* corn (over)use in North America tell us?
12:30	Juan Luis Jurat-Fuentes	Identifying mechanisms and detecting resistance alleles to *Bt* corn in North America
12:50	Minghui Jin	Resistance mechanism of *Bt* toxin Vip3Aa in the invasive fall armyworm

13:10 *Lunch Break*

14:10 *Scientific Session 2*

Scientific Session 2: *Pre-breeding and breeding for resistance to key lepidopteran pests, improved yield and yield-related traits*

Session Organizers: Chapwa Kasoma, CABI, Lusaka, Zambia

14:10	Chapwa Kasoma	Introduction
14:20	Nancy Ngoma	Farmer-centered IPM: exploring sustainable alternatives for fall armyworm management in maize production systems
14:40	Chapwa Kasoma	Lower-risk IPM options for fall armyworm management in smallholder farming systems
15:00	P. Lakshmi Soujanya	Sustainable management of invasive fall armyworm *Spodoptera frugiperda* (J.E. Smith) through host plant resistance and intercropping systems
15:20	Daniel Mutyambai	Insect frass fertilizer upregulates maize defence genes and resistance against invasive fall armyworm pest
15:40	Yutao Xiao	Functional loss of CHS2 confers high-level resistance to *Bacillus thuringiensis* Vip3Aa in five corn pests

15:40 *Coffee/Tea Break*

16:10 ***Scientific Session 3***

Scientific Session 3: *Bridging research and practice: IPM for piercing-sucking insects in maize systems*

Session Organizers: Md Tafsir Nur Nabi Rashed, University of Florida, Gainesville, FL, USA & Amanda C. Hodges, University of Florida, Gainesville, FL, USA

16:10	Tafsir Rashed & Amanda Hodges	Introduction
16.20	Ashleigh Faris	Oklahoma's response to a re-emerging threat: the corn leafhopper and corn stunt disease
16:40	Isaac Esquivel	Understanding and managing piercing sucking insects in Florida corn
17:00	Tim Bryant	Stink bugs as pests of field corn in the southeastern United States
17.20	Tynara Possebom	Evaluating cost-time efficiency and precision of pheromone traps for stink bug monitoring

17:50 ***End of Day 1***

18:00 ***Transfer from MARDI Auditorium in Serdang to Palm Garden Hotel***

19:00 ***Individual Dinner Arrangements***

Wednesday, 29 October 2025

08:15 ***Bus Transfer from Palm Garden Hotel to MARDI Auditorium in Serdang***

08:45 ***Scientific Session 4***

Scientific Session 4: *Biological control of maize insect pests in the digital era*

Session Organizers: Feng Zhang, CABI, Beijing, China & Zheng Li, Institute of Plant Protection, Shandong Academy of Agricultural Sciences, Jinan, China

08:45	Feng Zhang & Zheng Li	Introduction
08:55	Ruijuan Wang	Mass production and field release of *Trichogramma* in main summer corn cultivating area of China
09:15	Hongmei Li	The effects of two types of biopesticides on egg parasitoids of fall armyworm
09:35	Can Zhao	Using unmanned aerial vehicle to release natural enemies against maize insect pests
09:55	Feng Zhang	Uptake of bioprotection products through digital tools for sustainable management of maize pests
10:15	Rui Tang	Behavioural regulatory technology developed for fall armyworm based on olfactory plasticity
10:35	Ulli Kuhlmann	CABI BioProtection Portal: the world's largest, free, online resource for registered biological crop protection products

10:50 ***Coffee/Tea Break***

11:20 ***Scientific Session 5***

Scientific Session 5: *Progresses in biological control of fall armyworm worldwide*

Session Organizers: Marc Kenis, CABI, Delémont, Switzerland

11:20	Marc Kenis	Introduction
11:30	Hensley Joy Labonete	Antifeedant, growth, and developmental effects of sublethal concentrations of botanical crude extracts on fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae)
11:50	Yongzhi Zhong	Coriander derived E-2-decenal repels fall armyworm through dedicated olfactory coding involving SfruOBP13
12:10	Mohd Masri Saranum	Local heroes: native biocontrol agents against fall armyworm in Peninsular Malaysia
12:30	Sihle Nakombe	Testing the efficacy of *Metarhizium rileyi* on *Spodoptera frugiperda* in lab bioassays
12:50	Marc Kenis	Update on classical biological control of fall armyworm using *Eiphosoma laphygmae*

13:10 ***Lunch Break***

14:10 Scientific Session 6

Scientific Session 6: *Sustainable management of fall armyworm in smallholder farming systems*

Session Organizer: Alison Watson, ASEAN FAW Action Plan Secretariat, Singapore; Tiantao Zhang, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing, China & Feng Zhang, CABI, Beijing, China

14:10	Alison Watson, Tiantao Zhang & Feng Zhang	Introduction
14:20	Macdonald Mubayiwa	Fall armyworm predation pressure in cereal agroecosystems – predator diversity, density and associated predation rates and patterns
14:40	Precious Mpofu	Fall armyworm herbivory in smallholder maize systems: implications for natural enemy activity and habitat management in Southern Africa
15:00	Vishal Gupta	Biological control strategies for sustainable management of fall armyworm (*Spodoptera frugiperda*) in maize
15:20	Sushil Kumar Gupta	Chemical strategies for management of fall armyworm (*Spodoptera frugiperda*) in maize
15:40	Hongran Li	Novel mito-nuclear combinations facilitate the global invasion of a major agricultural crop pest

16:00 ***Coffee/Tea Break***

16:30 Poster Presentation Session & Exhibition

17:50 ***End of Day 2***

18:00 ***Transfer from MARDI Auditorium in Serdang to Palm Garden Hotel***

19:00 ***Individual Dinner Arrangements***

Thursday, 30 October 2025

08:15 ***Bus Transfer from Palm Garden Hotel to MARDI Auditorium in Serdang***

08:45 ***Scientific Session 6 (continued)***

Scientific Session 6: *Sustainable management of fall armyworm in smallholder farming systems (continued)*

Session Organizers: Alison Watson, ASEAN FAW Action Plan Secretariat, Singapore; Tiantao Zhang, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing, China & Feng Zhang, CABI, Beijing, China

09:00	Tiantao Zhang	Field demonstration of fall armyworm management in Kenya and Ghana
09:20	Wee Tek Tay	Integrating genomics and genome scans for the sustainable management of *Spodoptera frugiperda* (Lepidoptera: Noctuidae)
09:40	Sivapragasam Annamalai	Invasion and adaptation: recurrent infestations of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith), on rice in the Philippines
10:00	Alison Watson	Collaborative action against fall armyworm in Southeast Asia: progress, challenges, and future directions

10:20 ***Coffee/Tea Break***

10:50 ***Scientific Session 7***

Scientific Session 7: *Integrated pest management tools and packages for maize pests*

Session Organizers: Stefan Toepfer, CABI, Hodmezovasarhely, Hungary & Xun Yan, Zhongkai University of Agriculture and Engineering, Guangzhou, China

10:50	Stefan Toepfer & Xun Yan	Introduction
11:00	Hannalene Du Plessis	Changing practices favour cutworms and increase their pest status in maize and soybean in South Africa
11:20	Macdonald Mubayiwa	Climate change threatens the suitability of *Telenomus remus* for fall armyworm biological control
11:40	Xun Yan	Combination use of entomopathogenic nematodes and botanical spray oil for the control of fall armyworm in maize
12:00	Hongqiang Feng	A network of high-resolution vertical-looking radar for automatic monitoring of high-flying insects over a wide area
12:20	Stefan Toepfer	Developing an IPM toolbox against fall armyworm in Europe

12:40 ***Lunch Break***

13:40 ***Scientific Session 7 (continued)***

Scientific Session 7: *Integrated pest management tools and packages for maize pests (continued)*

Session Organizers: Stefan Toepfer, CABI, Hodmezovasarhely, Hungary & Xun Yan, Zhongkai University of Agriculture and Engineering, Guangzhou, China

13:40	Fletcher Robbins	Unraveling patterns in the Corn Belt: impacts of connectivity in corn agroecosystems on a common pest of corn (*Agrotis ipsilon*)
14:00	Jingfei Guo	Graphene oxide enhances the dual role of *Beauveria bassiana* in biocontrol of the Asian corn borer and promotion of the maize seedling growth under field conditions
14:20	Y. Andi Trisyono	Threats of corn production in Indonesia due to *Ostrinia furnacalis* and *Spodoptera frugiperda*
14:40	Mazidah Mat	Integrated pest management for fall armyworm (*Spodoptera frugiperda)* control of grain corn in Malaysia

15:00 ***Scientific Session 8***

Scientific Session 8: *Free themes*

Session Organizers: Ulli Kuhlmann, CABI, Delémont, Switzerland

15:00	Henly Joy Labonte	Biogeographic risk mapping of fall armyworm (*Spodoptera frugiperda*) in Iligan city based on farm level and climatic data
15:20	Yan Peng	Landscape of structural variants reveals insights for local adaptations in the Asian corn borer

15:40 ***Coffee/Tea Break***

16:10 IWGO Business Meeting

16:30 Guided Tour through the MARDI Campus

17:50 ***End of Day 3***

18:00 Transfer from MARDI Auditorium in* Serdang *to Palm Garden Hotel

19:00 ***Farewell Dinner Palm Garden Hotel***

Friday, 31 October 2025

Excursion (optional booking required)

08:00 ***Meeting in the lobby of the Palm Garden Hotel***

15:00 ***Arrival Palm Garden Hotel***

15:00 ***End Excursion***

POSTER PRESENTATIONS

Poster 01	Tingting Xu	Cross-resistance between Cry1Ab toxin and abamectin in *Ostrinia furnacalis*
Poster 02	Ongani Chirwa	Characterization of 25 Zambian maize landraces for resistance to key lepidopteran pests
Poster 03	Taynara Possebom	Understanding pheromone traps for monitoring stink bug populations
Poster 04	Hannalene Du Plessis	Susceptibility of *Spodoptera frugiperda* to commercial entomopathogenic fungi formulations in South Africa
Poster 05	Xun Yan	Persistence of entomopathogenic nematodes after above-ground application indifferent formulations onto maize plants
Poster 06	Wan Muhammad Azrul Wan Azhar	Potential of *Metarhizium anisopliae* for sustainable management of *Spodoptera* spp. in maize
Poster 07	Zulaikha Mazlan	The effectiveness of commercial pheromone lures for monitoring fall armyworm in Malaysia
Poster 08	Stefan Toepfer	Evaluating insecticidal and repellent effects of botanical compounds against adult western corn rootworm (*Diabrotica virgifera virgifera*)
Poster 09	Md Tafsir Nur Nabi Rashed	Doctor of Plant Medicine: preparing professionals to address global plant health challenges

ABSTRACTS
ORAL
PRESENTATIONS

Session 1-T 1 - Recent research and extension efforts in North America to delay *Bt* resistance in maize pests

Safeguarding *Bt* maize and cotton with experimental social science evidence

Dominic Reisig[1]

[1]*North Carolina State University, Plymouth, North Carolina, USA, ddreisig@ncsu.edu*

In the southern US, maize growers are mandated to plant a minimum of 20% of their acreage to non-*Bt* hybrids (refuge). In part, this helps delay *Helicoverpa zea Bt* resistance in cotton. Previous efforts to boost refuge plantings failed, but a pilot study suggested emotional stories during in-person extension meetings might help. We conducted surveys and economic experiments during 2023 extension meetings to measure grower conditional cooperation (I'll cooperate if you do). Half received information on planting refuge, while the rest got the same information with a short emotional appeal. This region has a history of drainage management, with varying cooperation levels among farmers. We hypothesized that belonging to drainage management districts would make growers more conditionally cooperative and receptive to the emotional appeal. The group with the emotional appeal was 16% more likely to plant some refuge and 20% more likely to plant enough. Membership in a drainage management group significantly affected behavior during the experiment. Drainage management participants were three times more likely to be conditional cooperators and six times more likely to be altruists. They were more inclined to plant some refuge but didn't respond to the emotional appeal. In contrast, the emotional appeal had a bigger impact on less cooperative, individualistic groups. We believe that growers with higher conditional cooperation levels, especially in drainage management districts, are more open to area-wide management strategies. Social capital and emotional appeals have the potential to promote non-*Bt* maize refuge, thereby delaying insect resistance to *Bt* maize in the southern US.

Session 1-T 2 - Recent research and extension efforts in North America to delay *Bt* resistance in maize pests

Resurgence of European corn borer in Canada

Jocelyn Smith, Yasmine Farhan, Emily Glasgow, Jenna Straughan, Josee Kelly and Rebecca Hallett

University of Guelph, Ridgetown, Ontario, Canada, jocelyn.smith@uoguelph.ca

The European corn borer (ECB), *Ostrinia nubilalis* (Lepidoptera: Crambidae), was the primary target of transgenic *Bt* corn, which has remained one of the most successful pest management tools in North American agriculture for over 25 years. Until recently, ECB populations showed no evidence of field-evolved resistance to *Bt* toxins; however, this shifted following the first detection of *Bt*-resistant ECB in Nova Scotia, Canada, in 2018. Subsequent resistance detections in Quebec (2019) and Manitoba (2020) indicate that resistance is more geographically widespread than initially anticipated. In 2023, the first *Bt*-resistant ECB populations were also identified in Connecticut, USA, further underscoring the urgency of this emerging threat.

This presentation will review the chronology and geographic spread of *Bt*-resistant ECB populations in Canada, highlighting the surveillance and diagnostic methods used to detect resistance. Understanding the distribution, mechanisms, and potential economic impacts of *Bt* resistance in ECB is critical for sustaining the benefits of *Bt* corn, supporting grower decision-making, and informing future resistance management strategies across North America.

Session 1-T 3 - Recent research and extension efforts in North America to delay *Bt* resistance in maize pests

Evolution of southwestern corn borer, *Diatraea grandiosella*, resistance to plant incorporated *Bacillus thuringiensis* proteins in maize

David Kerns, Fabio Fuhr and Haley Kennedy

Texas A&M University, College Station, Texas, USA, david.kerns@ag.tamu.edu

Diatraea grandiosella (Dyar) (Lepidoptera: Crambidae), commonly known as the southwestern corn borer (SWCB), is a significant pest of maize, primarily causing yield losses through stalk tunneling and plant lodging. The introduction of genetically modified corn expressing *Bacillus thuringiensis* (Berliner) (Bacillales: Bacillaceae) (*Bt*) insecticidal proteins has significantly reduced *D. grandiosella* as an economic pest in the United States. However, in 2023, severe damage attributed to *D. grandiosella* was reported in Antelope Wells, New Mexico, on corn hybrids expressing the *Bt* proteins Cry1Ab and Cry1F. In 2024, similar injuries were observed on hybrids expressing Cry1A.105, Cry1F and Cry2Ab2. In this study, we investigated *Bt* resistance in SWCB larval in southwest New Mexico. We conducted dose-response diet-overlay bioassays using a laboratory-susceptible SWCB strain to estimate the diagnostic concentration for Cry1A.105, Cry1F, Cry2Ab2, and Vip3Aa39 proteins. Subsequently, F2 screens were performed using two field populations collected in 2023 and 2024 from Antelope Wells, New Mexico to estimate resistance allele frequencies for these proteins, followed by full-range dose–response bioassays on F2 survivors. Estimated resistance allele frequencies were 0.1275 for Cry1A.105, 0.1381 for Cry1F, 0.0814 for Cry2Ab2, and 0.0000 for Vip3Aa39. Resistance ratios were approximately 200-fold for Cry1A.105, 55-fold for Cry1F, and over 11-fold for Cry2Ab2. No resistance was detected to Vip3Aa39. These findings provide evidence for the evolution of *Bt* resistance in *D. grandiosella* to Cry proteins, likely contributing to the observed injuries through reduced susceptibility in these populations. Continued research on resistance management is essential for sustainable pest management of SWCB.

Session 1-T 4 - Recent research and extension efforts in North America to delay *Bt* resistance in maize pests

Managing a billion-dollar bug: *Bt* resistance of European corn borer in Minnesota and Wisconsin (U.S.)

Tatum Dwyer and Fei Yang

University of Minnesota Twin Cities, Saint Paul, Minnesota, USA, dwyer332@umn.edu

The European corn borer (ECB), *Ostrinia nubilalis* (Hübner), is a major stalk-boring insect pest of corn. Late-instar larvae are the primary cause of crop injury, resulting in an estimated $1 billion in annual economic losses from yield reduction and control measures. Transgenic corn expressing *Bacillus thuringiensis* (*Bt*) proteins was developed to target ECB larvae in 1996, with the first commercial *Bt* corn product containing the Cry1Ab protein. Since then, three additional i proteins, Cry1F, Cry1A.105, and Cry2Ab2, have been registered for ECB control. The widespread adoption of *Bt* corn, combined with insect resistance management (IRM) strategies, such as the high-dose refuge and gene pyramiding, has enabled long-term suppression of ECB populations. However, practical resistance to Cry1F in ECB was first documented in Canada in 2018, and then field-evolved resistance to Cry1A.105 and Cry2Ab2 was reported in Connecticut in 2023. To ensure the continued effectiveness of current IRM strategies, it is critical to understand resistance allele frequencies, inheritance of resistance, cross-resistance and fitness costs associated with the Bt resistance. In this study, we conducted F2 screens of ECB against Cry1Ab, Cry1F, Cry1A.105 and Cry2Ab2 proteins with populations collected from Minnesota and Wisconsin during 2023 - 2024; characterized the inheritance of Cry2Ab2 resistance in multiple ECB populations; assessed the fitness costs associated with the Cry2Ab2 resistance; and evaluated the cross-resistance patterns between Cry2Ab2 resistance and Cry1 *Bt* proteins. Data for this research are foundational to IRM and pest control, supporting the sustainable use of *Bt* technology for ECB control.

Session 1-T 5 - Recent research and extension efforts in North America to delay *Bt* resistance in maize pests

Corn rootworm resistance management in the presence of crop rotation and seed-blends

Michael Caprio

Mississippi State University, Mississippi, USA, MCaprio@entomology.msstate.edu

In the US there is often a mixture of continuous corn (fields planted to corn year after year) and rotated corn, most often in a 2-year rotation of corn and soybean. Longer rotations are also utilized by some growers. We examine the implications of continuous corn in regions with a high proportion of rotated corn. Because continuous corn produces adult CRW while in rotated corn adult production is either eliminated or severely reduced, resistance evolution is driven primarily by populations developing in continuous corn despite the predominance of rotated corn. Augmenting control in continuous corn does little to alter resistance evolution unless there is an alternative source of unselected individuals. Given that sorter rotations (2 and 3-year) likely produce few adults, these fields cannot be seen as refuges. This leads to the surprising conclusion that even if 90% of the fields in a region are planted to non-*Bt* corn in a 2-year rotation, resistance will evolve at the same rate as if the entire region was planted to continuous corn.

Commercial strategy of transgenic insect-resistant maize in China

Guoping Li

Institute of Plant Protection, Henan Academy of Agricultural Sciences, Zhengzhou, China, liguoping1976@163.com

As a new generation of pest control technology, transgenic insect-resistant corn was commercially planted in the United States in 1996, and quickly spread to major corn producing countries such as Brazil and other areas, becoming a core technology for the control of major pests such as fall armyworm *Spodoptera frugiperda* and European corn borer *Ostrinia nubilalis*. In this paper, the commercial history of transgenic insect-resistant maize and its role in pest control in the world were reviewed, and the successful experiences of the United States in the management of resistance to target pests such as corn borer and fall armyworm were analyzed, as well as the causes and lessons of resistance of fall armyworm to various transgenic insect-resistant maizes in Brazil and other South American countries. Based on the research and development status of transgenic insect-resistant maize transformation events in China, maize production patterns, regional occurrence characteristics and migratory biology of maize pests, it was proposed to plant multi-gene stacked insect-resistant maize cultivars containing Vip3A at the source for prevention and control of fall armyworm in mountainous and hilly maize areas of southern and southwestern China. In the Huang-Huai-Hai summer maize region, multi-gene stacked resistant maize containing Cry2A should be planted for the prevention and control of cotton bollworm *Helicoverpa armigera* at the source; in the northern spring maize region, multi-gene stacked resistant maize containing Cry1A should be planted for the prevention and control of Asian corn borer *O. furnacalis* at the source, and planting Cry3b- and Cry34/35A-resistant corn in the areas with serious occurrence of two-spotted leaf beetle *Monolepta hieroglyphica*, was proposed. To implement the high dose/refuge resistance management strategy in China, it is necessary to register the target pest species based on whether the transformation event meets the high dose criterion for pests. In terms of the refuge setting for current products, 10–20% structured refuge should be applied to the resistant corn for management of fall armyworm *S. frugiperda* and the single *Bt* gene resistant corn, while 5% seed mixed refuge should be applied to the multi-gene resistant corn for pest control, such as Asian corn borer *O. furnacalis*.

Session 1-T 7 - Recent research and extension efforts in North America to delay *Bt* resistance in maize pests

What can the first 20 years of *Bt* corn (over)use in North America tell us?

Christian Krupke

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Since the mid-1990s, genetically engineered maize for insect control has been enthusiastically and rapidly adopted by policymakers and the seed industry. However, this widespread adoption has shown pitfalls, most notably when overuse of the technology simultaneously erodes the pest susceptibility resource, whilst growers pay a premium for genetic traits that may not be necessary or effective. A recent collaboration between entomologists and agricultural economists across the corn-producing regions of the US and Canada revealed co-occurring trends of declining protection from rootworm feeding (i.e. pest resistance) coupled with declines in overall pest pressure in the years immediately following the commercial release of the technology. This deployment strategy is effectively the opposite of IPM/IRM approaches that stress judicious use of pest management tools by aligning use of tools with pest risk. This presentation will highlight our results with case studies from the eastern and western US Corn Belt, explore the reasons behind them, and place these results within the context of novel and future approaches to management of maize pests using transgenic hybrids.

Session 1-T 8 - Recent research and extension efforts in North America to delay *Bt* resistance in maize pests

Identifying mechanisms and detecting resistance alleles to *Bt* corn in North America

Rajeev Roy[1], Dawson Kerns[1], Tom Ruttink[2], Peter Tandy[1], Kurt Lamour[1], David Kerns[3], Fangneng Huang[4], Yasmine Farhan[5], Jocelyn Smith[5], Fei Yang[6] and Juan Luis Jurat-Fuentes[1]

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[2]*Flanders Research Institute for Agriculture, Fisheries and Food, Belgium*
[3]*Texas AM University, Texas, USA*
[4]*Louisiana State University, Louisiana, USA*
[5]*University of Guelph, Ontario, Canada*
[6]*University of Minnesota, Minnesota, USA*

Transgenic corn hybrids producing Cry and Vip3Aa insecticidal proteins from the bacterium *Bacillus thuringiensis* (*Bt* corn) are used to control lepidopteran pests in North America. However, three of the most relevant targets of *Bt* corn, the European corn borer (ECB, *Ostrinia nubilalis*), the corn earworm (CEW, *Helicoverpa zea*), and the fall armyworm (FAW, *Spodoptera frugiperda*), have evolved practical resistance to insecticidal traits in *Bt* corn. This presentation will review recent research elucidating the mechanisms of resistance to Cry and Vip3Aa proteins in populations of ECB, CEW, and FAW, and efforts to develop a highly multiplexed (HiPlex) targeted sequencing approach for DNA-based resistance monitoring.

Session 1-T 9 - Recent research and extension efforts in North America to delay *Bt* resistance in maize pests

Resistance mechanism of *Bt* toxin Vip3Aa in the invasive fall armyworm

Minghui Jin and Yutao Xiao

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Transgenic crops producing insecticidal proteins from *Bacillus thuringiensis* (*Bt*) have revolutionized control of some major pests. However, more than 25 cases of field-evolved practical resistance have reduced the efficacy of transgenic crops producing crystalline (Cry) *Bt* proteins, spurring adoption of alternatives including crops producing the *Bt* vegetative insecticidal protein Vip3Aa. Although practical resistance to Vip3Aa has not been reported yet, better understanding of the genetic basis of resistance to Vip3Aa is urgently needed to proactively monitor, delay, and counter pest resistance. This is especially important for fall armyworm (*Spodoptera frugiperda*), which has evolved practical resistance to Cry proteins and is one of the world's most damaging pests. Here, we report the identification of an association between downregulation of the transcription factor gene SfMyb and resistance to Vip3Aa in *S. frugiperda*. Results from a genome-wide association study, fine-scale mapping, and RNA-Seq identified this gene as a compelling candidate for contributing to the 206-fold resistance to Vip3Aa in a laboratory-selected strain. Experimental reduction of SfMyb expression in a susceptible strain using RNA interference (RNAi) or CRISPR/Cas9 gene editing decreased susceptibility to Vip3Aa, confirming that reduced expression of this gene can cause resistance to Vip3Aa. Relative to the wild-type promoter for SfMyb, the promoter in the resistant strain has deletions and lower activity. Data from yeast one-hybrid assays, genomics, RNA-Seq, RNAi, and proteomics identified genes that are strong candidates for mediating the effects of SfMyb on Vip3Aa resistance. The results reported here may facilitate progress in understanding and managing pest resistance to Vip3Aa.

Session 2-T 1 - Pre-breeding and breeding for resistance to key lepidopteran pests, improved yield and yield-related traits

Farmer-centered IPM: exploring sustainable alternatives for fall armyworm management in maize production systems

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Fall armyworm (*Spodoptera frugiperda*) is the leading insect pest of maize, Zambia's main staple crop that is predominantly produced by smallholder farmers. Since the first appearance of the pest in the country, farmers have relied on spraying chemical pesticides indiscriminately, posing a threat to biodiversity. Recognizing the adverse effects of chemical pesticides, research has been ongoing to develop nature-friendly options for managing the pest. This study aims to provide a farmer's perspective on the performance of an IPM package for FAW management that integrates host resistance, biological control and farmers' cultural practices. The first FAW tolerant maize variety released in Zambia in combination with a FAW nuceopolyhedrovirus will be evaluated in a randomised complete block design study. Evaluation trials involving three treatments including a FAW tolerant maize + nucleopolyhedrovirus combination, a chemical pesticide positive control and an untreated negative control were established at two farmer locations in August 2025 in Chongwe, Zambia. Data on maize agronomic and FAW-related traits including plant height, FAW associated leaf damage at different maize growth stages, FAW-inflicted cob damage and grain yield will be collected using visual assessments and standard rating scales. Analysis of variance will be performed on the data to determine the differences between the experimental treatments. Findings from this study will provide useful farmer feedback on the performance of Zambia's first released FAW-tolerant maize hybrid in an IPM scheme. This information is important for designing approaches for the deployment of improved varieties and nature-positive pest management alternatives among smallholder farming communities.

Session 2-T 2 - Pre-breeding and breeding for resistance to key lepidopteran pests, improved yield and yield-related traits

Lower-risk IPM options for fall armyworm management in smallholder farming systems

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Fall armyworm (FAW) (*Spodoptera frugiperda*) is one of the most damaging invasive species of maize in Africa. In Kenya and Zambia, the use of synthetic pesticides poses risk to biodiversity and human health. There is need to device sustainable and nature-positive pest management solutions. This research initiates an IPM approach combining host plant resistance and biological control using baculoviruses at the farm level to manage FAW. FAWLIGEN is a biological insecticide based on the *Spodoptera frugiperda* nucleopolyhedrovirus for the specific control of FAW larvae. The larvae must ingest the virus to be infected and subsequently killed by the virus depending on the ingested quantity and timing of virus ingestion. Field experiments to assess the efficacy of the baculovirus-based farmers' biopesticide combined with host plant resistance conferred by ZMS605 against FAW in maize were initiated in Zambia in 2025. Five treatments including the farmers' biopesticide, FAWLIGEN, *Metarhizium*, and emamectin benzoate and an untreated control will be applied. The trials are managed under smallholder production practices during the off-season period. Both agronomic and FAW related data are collected weekly to compare the performance of the treatments. We will assess whether the combination of host resistance, biological control and farmers practices provides a practical option for FAW management especially among resource-challenged farmers. The results from this study will inform the use of nature-positive pest management and its deployment in smallholder farming systems.

Key words: Baculovirus, biopesticide, chemicals, FAWLIGEN, host resistance, *Spodoptera frugiperda*

Session 2-T 3 - Pre-breeding and breeding for resistance to key lepidopteran pests, improved yield and yield-related traits

Sustainable management of invasive fall armyworm *Spodoptera frugiperda* (J.E. Smith) through host plant resistance and intercropping systems

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Maize (*Zea mays* L.) is the most significant cereal crop cultivated globally and exhibits superior adaptability to diverse environmental conditions. Fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), represents a serious invasive pest impacting maize production worldwide. The recent rapid dissemination of FAW to Africa and Asian nations, including India, poses a substantial threat to global food security. It has been reported that FAW damage can reduce maize yields by approximately 50-80%, resulting in losses amounting to millions of dollars. The sudden invasion of FAW in India has led to numerous recommendations advocating for the use of chemical insecticides as foliar sprays. The use of these toxic chemicals has contributed to pest resistance development, toxicity to beneficial fauna, pest resurgence, and poses environmental and human health risks. Consequently, there is a critical need for cost-effective, environmentally sustainable management strategies that control FAW without compromising grain yield. In this context, host plant resistance (HPR) emerges as a highly promising, cost-effective, and environmentally friendly pest control strategy against FAW. Several maize germplasm varieties have been evaluated for resistance to FAW under artificial infestation conditions at ICAR-IIMR since 2019. Genotypes such as DMRE 63, CML 67, CML 71, CML 141, CML 337, CML 346, and the wild ancestor *Zea mays* ssp. *parviglumis* were identified as promising based on leaf damage ratings (LDR) under artificial infestation conditions. The resistant lines identified are currently being incorporated into breeding programs at ICAR-IIMR, with extensive efforts underway to develop insect-resistant maize genotypes. In addition to host plant resistance, agro-ecological approaches such as diversification of intercrops are effective in mitigating FAW damage, as these methods are eco-friendly, target-specific, and enhance resilience sustainably (Hailu *et al.*, 2018). Location-specific intercropping of maize with crops such as cowpea, groundnut, green gram, and black gram has demonstrated reductions in FAW damage, increases in natural enemy populations, suppression of weeds, and improved maize yields compared to monocultured systems. Implementing host plant resistance and intercropping strategies in maize cultivation reduces reliance on synthetic insecticides and holds substantial potential to improve the livelihoods of smallholder maize farmers.

Session 2-T 4 - Pre-breeding and breeding for resistance to key lepidopteran pests, improved yield and yield-related traits

Insect frass fertilizer upregulates maize defence genes and resistance against invasive fall armyworm pest

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Black soldier fly frass fertilizer (BSFFF) has gained global attention as a multipurpose input for soil improvement, pest and disease management. However, studies examining its effects on pest resistance and the underlying mechanisms are limited. We investigated the impact of amending soil with BSFFF on maize growth, defense gene expression and resistance to a polyphagous pest, *Spodoptera frugiperda* through larval feeding assay. Maize growth was evaluated by measuring plant height, chlorophyll concentration, and biomass in soils amended with BSFFF, synthetic fertilizers (Di-ammonium phosphate and Calcium ammonium nitrate) and unfertilized soils at various growth stages. Larval feeding assays were conducted using leaf discs from maize plants grown in different amended soils. The expression level of three maize defense genes: pathogenesis related protein 5 (pr-5), maize proteinase inhibitors (mpi), and lipoxygenase 3 (lox-3) were analyzed using quantitative polymerase chain reaction (qPCR) while yield was assessed through field trials over two cropping seasons. Maize plants grown in BSFFF amended soils showed 30% more growth, higher chlorophyll, 0.93–2.86 t ha^{-1} higher yield, and 48% better nitrogen use efficiency than from those in synthetic or unfertilized soils. Moreover, *S. frugiperda* larvae consumed significantly less leaf tissue from maize plants grown in BSFFF amended soils than synthetically- and non-fertilized soils. Maize defense genes pr-5, mpi, and lox-3 were highly expressed both constitutively and inductively in maize planted in BSFFF amended soils compared to those grown in synthetically fertilized and non-fertilized soils. We noted a significant negative correlation between mpi gene expression and larval feeding, suggesting its role in maize resistance. Our results show that soil amendment with BSFFF strengthens plant defense systems and positively impacts plant growth and yield, contributing to increased agricultural productivity and sustainability.

Session 2-T 5 - Pre-breeding and breeding for resistance to key lepidopteran pests, improved yield and yield-related traits

Functional loss of CHS2 confers high-level resistance to *Bacillus thuringiensis* Vip3Aa in five corn pests

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Bacillus thuringiensis (*Bt*) crops, which produce insecticidal proteins such as Vip3Aa and Cry toxins, have revolutionized pest management by reducing reliance on chemical pesticides. However, the evolution of resistance in target pests has prompted investigation into the underlying mechanisms. A recent study identified a mutation in the chitin synthase gene (SfCHS2) as a key factor in Vip3Aa resistance in *Spodoptera frugiperda*. Here, we examined the role of CHS2 in resistance in other two additional lepidopteran species: *Spodoptera exigua* and *Agrotis ipsilon*. Togather with three species reported by us, we proved that CHS2 is a key factor in Vip3Aa resistance for at least five lepidopteran pests.

Session 3-T 1 - Bridging research and practice: IPM for piercing-sucking insects in maize systems

Oklahoma's response to a re-emerging threat: the corn leafhopper and corn stunt disease

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An outbreak of the corn leafhopper (CLH), *Dalbulus maidis* (Hemiptera: Cicadellidae), was reported in OK, TX, MO, and KS in 2024. Symptoms of corn stunt (CS) disease were also observed in several states in the Southern, Great Plains, Corn Belt, and Northeastern regions, with the main pathogen associated with CS disease (*Spiroplasma kunkelii*) molecularly characterized in OK, MO, AR, KS, NE, SD, WI, MN, NY, IN and TX. Yield losses of 10-55% due to CS disease were recorded in OK and MO commercial and sweet corn in 2024. As of July 20, 2025, the CLH has been detected in TX, OK, MO, and KS with CS symptoms already observed in TX and OK. This movement of the CLH northward follows a similar timeline as the 2024 expansion. CLH is an invasive vector that originated in Mexico. For years, this pathosystem was considered of secondary importance in corn-producing regions in the Americas, but since 2015, it has re-emerged as a major threat. As of 2025, CLH and CS pathogens have been recognized as such by the Southern and North Central Integrated Pest Management (IPM) Centers. The 2024 incursion was not the first time that U.S. corn production has seen CLH and CS disease. However, the re-emergence and expanded incursion of CLH into the U.S. Great Plains and Corn Belt states can have severe economic consequences for corn production, since there is no curative strategy for CS disease once corn stunt pathogens infect the crop. The high efficiency with which CLH acquires and transmits CS pathogens challenges management, as there are no established threshold levels for insecticide applications and all CLH are assumed to be viruliferous. Effective control of the CLH with foliar insecticides is further hindered by their mobility and rapid reproduction. Insecticide seed treatments offer limited CLH control due to their short residual activity. In addition to management of the pest, proper identification of the small and highly mobile CLH in the field has also brought about challenges.

In this presentation, we will discuss the response that Oklahoma State University extension specialists have had to the unique challenges of the CLH and CS disease on a local, statewide, and regional scale. This talk will highlight collaborations with corn growers, commodity boards, industry partners, researchers, and extension personnel that have been pivotal for eliciting a rapid response to a re-emerging threat.

Session 3-T 2 - Bridging research and practice: IPM for piercing-sucking insects in maize systems

Understanding and managing piercing sucking insects in Florida corn

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Florida's grain corn output is modest relative to leading U.S. corn-producing states, producing 6.63 million bushels in 2024, but it plays an important role in the state's field and row crop sector. Florida also produces a significant amount of silage corn; about 34,000 acres were harvested for silage in 2024, which complements grain corn in the state's agricultural system. In 2025, Florida is expected to harvest roughly 50,000 acres of grain corn, which is a 5% increase from 2024. Corn is planted earlier in Florida than most of the U.S, which makes the pest complex and management of those pests challenging, or not. In recent seasons, shifts in pest species composition, extended activity periods, and changing agricultural practices have amplified the challenge for growers. This presentation will provide an overview of the current hemipteran pest complex in Florida corn, highlighting trends in pest abundance, distribution, and associated crop impacts. Emphasis will be placed on the collaborative efforts between entomologists, extension specialists, and growers to monitor pest populations, develop integrated pest management strategies, and rapidly disseminate recommendations.

Session 3-T 3 - Bridging research and practice: IPM for piercing-sucking insects in maize systems

Stink bugs as pests of field corn in the southeastern United States

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Stink bugs are one of the most important economic pests of field corn in the southeastern United States. There are several common species, including the brown marmorated stink bug, *Halymorpha halys*, brown stink bug, *Euschistus servus*, the green stink bug, *Chinavia hilaris*, and the southern green stink bug, *Nezara viridula*. While these insects have the potential to cause significant economic injury, they occur sporadically and are able to move readily between suitable cultivated and wild hosts. As such, it is critical to understand the pests' ecology to guide scouting efforts and implement management strategies effectively. This talk will cover research that has been conducted in the southeastern United States on stink bug ecology and integrated pest management.

Session 3-T 4 - Bridging research and practice: IPM for piercing-sucking insects in maize systems

Evaluating cost-time efficiency and precision of pheromone traps for stink bug monitoring

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Stink bugs (Hemiptera: Pentatomidae) are significant agricultural threats in the southern US, causing extensive economic damage across multiple crops. Over the past four years, these insects have caused an annual yield loss of approximately 7.17 million bushels in corn and $300 million in soybean losses and costs. While growers currently rely primarily on field-based direct scouting techniques, indirect monitoring systems could support current scouting approaches. However, researchers must determine the precision and cost-effectiveness of different monitoring tools to select optimal trap types. We evaluated the precision and efficiency of various pheromone trap designs for stink bug monitoring in terms of both time and cost requirements. Using individual fields as experimental replicates, we deployed seven pheromone trap types across 68 soybean fields during August through December in 2023 and 2024. We tested two pheromone lure formulations targeting different stink bug species with each trap type. We monitored traps biweekly, counted and identified captured stink bugs to species, and replaced lures or traps as needed. We conducted sweep net sampling (100 sweeps per field at 15-row intervals from trap locations). We assessed trap precision and efficiency using relative variation and relative net precision calculations applied to stink bug capture data. Results demonstrated significant variation in trap performance depending on both trap design and lure formulation. Our results indicate that pheromone traps have promise as reliable monitoring tools for stink bug management, with applicability in corn and other host crops utilized by these pests.

Mass production and field release of *Trichogramma* in main summer corn cultivating area of China

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Trichogramma wasps are important natural enemies of lepidopteran pests and have been widely used in the biological control of corn pests. Research has shown that different species of *Trichogramma* exhibit preferences for Asiatic corn borers in different regions. In the Huang-Huai-Hai region of China, *Trichogramma ostriniae* has demonstrated superior parasitism effectiveness against Asiatic corn borers. Based on the dynamic monitoring of corn borer populations, the optimal release strategy for *Trichogramma* was determined. The key release period was identified as the silking stage of corn. According to the occurrence of pests in corn fields across Shandong Province, *T. ostriniae* and *T. dendrolimi* were released to control corn borers. Field application surveys conducted over eight consecutive years (2015–2022) showed that the egg mass parasitism rate in fields with *T. ostriniae* releases consistently exceeded 90%, significantly higher than that in chemically controlled fields. In terms of *Trichogramma* rearing, “small eggs” (*Corcyra cephaonica* and *Sitotroga cerealella*) were used to rear *T. ostriniae* and *T. dendrolimi*. This led to the establishment of a large-scale production line and the development of a series of rearing equipment. Currently, a factory-based rearing process for *Trichogramma* using small host eggs has been successfully implemented, as well as the application of *Trichogramma* in main summer corn cultivating area of China.

Session 4-T 2 - Biological control of maize insect pests in the digital era

The effects of two types of biopesticides on egg parasitoids of fall armyworm

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To optimize pest management strategies, it is essential to identify pesticides that effectively control pests while posing minimal risks to biological control agents. Through research conducted first in the laboratory and then in the field, optimal combinations of control measures can be determined by evaluating their impact on biological control agents. Two commercially available biopesticides, *Bacillus thuringiensis* (*Bt*) G033A and *Metarhizium anisopliae* (Ma) CQMa421, were evaluated for their potential side effects on the parasitoid *Trichogramma chiloni*, the key biological control agent for managing the fall armyworm (FAW) in China. The results revealed that neither biopesticide significantly affected the parasitism behavior of *T. chilonis* on FAW egg masses or individual eggs, nor did they impact the developmental period of the parasitoid progeny in both laboratory and semi-field experiments. However, slight effects on parasitoid emergence were observed when the biopesticides were applied after host eggs had been parasitized. Specifically, *Bt* G033A reduced the successful emergence of *T. chilonis* by 23.5%, indicating that *Bt* should not be applied immediately following releases of *T. chilonis*. In summary, both biopesticides are compatible with *T. chilonis* when applied at recommended doses.

Using unmanned aerial vehicle to release natural enemies against maize insect pests

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To solve the problems of releasing natural enemies especially for the tall stature crops such as maize, and to increase the efficacy and improve the traditional artificial approach of field releases, we investigated *Trichogramma* release method and tool with wasp-release balls and delivery device by using unmanned aerial vehicle (UAV) in recent years. The newly developed natural enemy products and release technologies with UAV have been successfully applied on crops such as rice, corn, and sugarcane. The densities of *Ostrinia furnacalis* (Guenée) larvae were reduced to 54. 55% after release of *Trichogramma* by UAV in corn fields. *Trichogramma* releases with the bio-degradable wasp ball against *Spodoptera frugiperda* (J.E. Smith, 1797) in corn fields resulted in an egg parasitism rate of 86.48%, a population reduction rate of 80.20%, and a control effect of 72.48%. The mixed-species release with a combination of 20% *Telenomus remus* and 80% *T. chilonis* was proved cost-efficient for the control of *S. frugiperda*. In summary, the technology of releasing natural enemies by UAV for the control of maize insect pests such as Asian corn borer and fall armyworm has brought significant economic and environmental benefits

Uptake of bioprotection products through digital tools for sustainable management of maize pests

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Maize is one of the most important crops worldwide, accounting for 12% of the global crop production in 2022. Despite its high productivity, maize yields are below their potential because of many abiotic and biotic stresses such as climate change, pests and diseases. Growers are still relying on synthetic chemical pesticides to control weeds, insect pests and diseases on maize production, which would cause negative impacts on environment and human health. There is a strong incentive to develop integrated pest management approaches with greater emphasis on using bioprotection products. However, the uptake of bioprotection products is still limited at larger scales. One of the limited factors to hinder widespread adoption of bioprotection products is lack of knowledge about these low-risk alternatives to hazardous chemical pesticides. To address this knowledge gap, CABI has developed a wide range of digital tools under the PlantwisePlus program, including the CABI BioProtection Portal. In this context, we will share and discuss the bioprotection products available to control maize pests globally. We will also introduce the tailor-made PlantwisePlus approaches being successfully implemented at the Qianwei county, Sichuan province, China, leading to 15% annual increase in application of green plant protection measures as well as reduction of chemical pesticide use in recent years.

Key words: digital tools; Zea mays; pesticides; integrated pest management; bioprotection

Session 4-T 5 - Biological control of maize insect pests in the digital era

Behavioral regulatory technology developed for FAW based on olfactory plasiticity

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Spodoptera frugiperda is an aggressive feeder that engages in diverse interactions with host plants and associated microbes through its chemosensory system. These interactions offer unique opportunities to develop behavioral regulation strategies that exploit the insect's sophisticated sensory pathways and underlying mechanisms. In this presentation, we highlight recent work that initiated this concept and successfully identified repellents and attractants derived from natural enemies as well as from host and non-host plants. We also introduce a reverse chemical ecology approach that integrates iso-RNAseq to investigate alternative splicing of odorant receptor genes, enabling the screening of novel ligands. This strategy aims to formulate regulatory "recipes" that target transcriptional pathways underlying trade-off mechanisms in both adults and larvae. Overall, our work focuses on the olfactory system of the fall armyworm and explores multiple behavioral regulation methods with strong potential to improve sustainable corn production practices.

CABI BioProtection Portal: the world's largest, free, online resource for registered biological crop protection products

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The CABI BioProtection Portal is the world's largest, free, online resource for registered biological crop protection products, designed to help growers and advisors identify safe and sustainable alternatives to chemical pesticides. Developed by CABI, an international not-for-profit agricultural development organization, the Portal's mission is to raise awareness and accelerate the adoption of bioprotection within integrated pest management (IPM) systems.

The Portal provides a comprehensive, searchable directory of nationally registered biocontrol and biopesticide products, complemented by practical guidance to support their effective use. Currently available in 17 languages and nearly 50 countries, the tool can be accessed online and offline via smartphones, tablets, and desktops, making it particularly valuable for extension services and farmers in diverse production contexts.

Bioprotection products, derived from natural organisms or compounds, are increasingly important in addressing challenges such as pesticide resistance, environmental contamination, and food safety concerns. For maize systems specifically, biological solutions can contribute to sustainable management of key pests, including fall armyworm (*Spodoptera frugiperda*), stem borers, and storage pests. Their use also contributes to regenerative agriculture by enhancing soil and ecosystem health, while aligning with international Sanitary and Phytosanitary (SPS) standards, helping growers maintain market access.

Developed in collaboration with public agencies, research institutions, and a wide range of private sector partners, including bioprotection companies and global food companies, the Portal is continually updated to ensure its resources remain relevant, practical, and science-based. By enabling wider adoption of nature-based solutions, the CABI BioProtection Portal supports the UN Sustainable Development Goals, particularly Zero Hunger, Responsible Consumption and Production, and Life on Land.

To learn more, visit: www.bioprotectionportal.com

Antifeedant, growth, and developmental effects of sublethal concentrations of botanical crude extracts on fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae)

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The fall armyworm (*Spodoptera frugiperda*) is a major crop pest in the Philippines, driving pesticide dependence and threatening food security. Building on ethnobotanical knowledge in pest control, this study tested crude aqueous extracts of chili (*Capsicum frutescens*), madre de cacao (*Gliricidia sepium*), and lemongrass (*Cymbopogon citratus*) against third-instar larvae under laboratory conditions as a sustainable alternative supporting integrated pest management (IPM). In the dose-setting experiment, *C. citratus* demonstrated the highest efficacy (LC_{30} = 51.3 g/L), followed by *C. frutescens* (65.6 g/L) and *G. sepium* (75.3 g/L), all showing more gradual dose-dependent toxicity than the positive control, Methomyl (LC_{30} = 0.00833 g/L). *C. citratus* also exhibited the strongest feeding deterrence ($p < 0.001$), with the lowest leaf consumption (28.65%), high antifeedant indices (AIDC: 45.09%; AINC: 24.16%), and the highest larval food conversion efficiency (ECI = 23.3%), while inducing malformations across developmental stages indicating both antifeedant and toxic effects. *C. frutescens* produced the greatest delayed toxicity, reflected in prolonged larval duration, the lowest survival rate (45%), and the highest incidence of malformations in pupae (28.6%) and adults (14.3%), despite moderate feeding suppression ($p = 0.011$), higher leaf consumption (33.68%), and the lowest antifeedant indices (AIDC: 37.94%; AINC: 14.66%). *G. sepium* recorded moderate survival (70%), higher consumption (29.96%), and minimal malformations, but achieved a high antifeedant index in dual-choice tests (AIDC: 49.21%) and a lower index in no-choice tests (AINC: 19.13%), These findings highlight the unique antifeedant and behavioral effects of botanical extracts, proving the validity of ethnobotanical knowledge in pest control and their potential as affordable, eco-friendly tools for small-scale farming, with further field testing recommended for sustainable use.

Coriander derived E-2-decenal repels fall armyworm through dedicated olfactory coding involving SfruOBP13

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The *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) is a globally invasive pest, and its management is primarily dependent on chemical pesticides, which has spurred the need for eco-friendly control strategies. The push-pull strategy, an environmentally friendly pest management approach, has shown promise in controlling *S. frugiperda*. In this study, using a combination of adult oviposition, larval feeding, and electrophysiological tests, we confirmed the repellent properties of coriander and its volatiles. Gas chromatography-mass spectrometry analysis of coriander volatiles revealed E-2-decenal as the major repellent compound. Furthermore, SfruOBP13 was identified as one of the main odorant-binding protein that detects E-2-decenal in the *S. frugiperda*, providing a molecular basis for the insect's perception of this volatile. These findings lay the groundwork for developing behavior-based pest control strategies, offering valuable insights for sustainable *S. frugiperda* management using plant-derived semiochemicals.

Local heroes: native biocontrol agents against fall armyworm in Peninsular Malaysia

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Fall armyworm (FAW) *Spodoptera frugiperda* (Lepidoptera: Noctuidae) is a new invasive pest in Malaysia. This pest originated in South America but has spread to Africa, Asia and further in Malaysia in 2019. *S. frugiperda* is known to attack over 350 crop species, with maize being among the most severely affected by its infestations causing losses to the farmers. Survey and collection of biocontrol agent for *S. frugiperda* were conducted from maize fields in Peninsular Malaysia. Collection of soil samples were also collected from several areas in Malaysia. The collected soils were brought back to the laboratory and baited with *Tenebrio molitor* larvae to obtain entomopathogenic microbes. Two species of egg parasitoids reared in MARDI, *Telenomus remus* was collected from FAW egg mass in maize fields in Sekinchan and was found to be a prolific eggs parasitoid for Noctuid moth including FAW with another generalist egg parasitoid, *Trichogramma chilonis* which can also parasitize FAW eggs. Two predators of FAW were also collected from Perlis and reared in MARDI were found to have potential as biological control. The predator namely *Euborellia annulipes* earwig and green lacewing *Plesiochrysa* sp. found to hunt and feed on FAW. From the soil baited, 2 entomopathogenic microbes consists of entomopathogenic fungi and entomopathogenic nematodes were obtained from dead larval body of *S. frugiperda* and *T. molitor*. Morphological identification found that the entomopathogenic fungi obtained were *Metarhizium rileyi*, *Metarhizium anisopliae* and *Paecilomyces lilacinus*. This entomopathogenic fungus was assessed on eggs, pupa, larvae and adult moths of FAW. Entomopathogenic fungi exert a lethal effect at each stage of *S. frugiperda*. Entomopathogenic nematode from the species *Steinernema* sp. is effective to control larval of FAW in laboratory bioassay studies. A complete mortality of the pests was achieved within 48 hours. This indicates the potential of our native biocontrol agents to manage FAW in Malaysia.

Keywords: Fall Armyworm (FAW), Parasitoids, Predators, Entomopathogenic Microbes, Native Biocontrol Agent

Testing the efficacy of *Metarhizium rileyi* on *Spodoptera frugiperda* in lab bioassays

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Fall armyworm (FAW), *Spodoptera frugiperda*, has incurred significant yield losses in Africa since its detection in 2016. In Zambia, maize, sorghum, millet and sugarcane have been severely affected mainly in regions with high temperatures and low rainfalls. While smallholder farmers have been managing FAW infestations using cultural and mechanical practices such as applying sand in whorls or picking and crushing eggs and larvae, these techniques are time consuming mainly for women and youth who are in charge of pest scouting. The ACIAR-funded project entitled Village-based biocontrol of fall armyworm in rural Zambia is investigating a local strain of *Metarhizium rileyi* to control FAW with smallholder farmers. We tested in laboratory bioassays 3 different concentrations (1x109 vs 3x109 vs 5x109 per ml or gram) and 2 types of formulations (liquid and dry). Preliminary results show that the liquid formulation kills about 50% of the larvae regardless of the concentration. The dry formulation kills 43% of larvae at 1x109 spores/g, and 60% at 3x109 and 5x109 per gram. The pick of mortality for the liquid formulation occurred at day 6 after inoculation and then slow down the following days killing 31% of the larvae between day 6 and 8. The pick of mortality for the dry formulation occurred at day 7 and 8 and killed 45% of the larvae between day 6 and 8 after inoculation. This difference in speed and effectiveness of killing the larvae is due to the time needed for the dry spores to germinate on the insects while the liquid formulation already contains germinated spores which need to be in contact with the insect within 24h before dying. The dry formulation offers longer efficacy and can continue infecting insects over a longer period of time. These bioassays will be tested in field trials to validate the best formulation to use in open field settings.

Update on classical biological control of fall armyworm using *Eiphosoma laphygmae*

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This work has been conducted by more than 20 scientists in four continents. Their specific contributions will be highlighted at the congress. Classical biological control of the fall armyworm (FAW), *Spodoptera frugiperda*, has been considered since the species was first observed in 2016 in West Africa. Literature surveys suggested that, among the most frequent parasitoids of FAW in tropical America, the ichneumonid larvae parasitoid *Eiphosoma laphygmae* is likely the most specific. Indeed, other important parasitoids of FAW have been tested in the laboratory in recent years and were successfully reared on several other Noctuidae. *Eiphosoma laphygmae* was collected in 2019 and 2023, in the region of Santa Cruz in Bolivia, where it is one of the main parasitoids of FAW. It was imported to the CABI quarantine laboratory in Switzerland. Rearing the parasitoid has been difficult from the beginning and, although progress has been made, it still cannot be mass-reared because parasitized larvae have to be reared individually. Specificity tests conducted in Switzerland and in Pakistan, where it was reared in quarantine by CABI for a year, confirmed that it is specific to FAW. It attacks some other noctuid larvae, in particular species of the genus *Spodoptera* but, so far, only two cocoons were obtained from specificity tests, both from *Spodoptera exigua*, and no adult emerged. Other tests on its biology were conducted, such as competition tests with the egg-larval parasitoid *Chelonus insularis*, which showed that *E. laphygmae* is competitively superior. So far, trials to transfer the rearing to other laboratories in Africa failed and, therefore, releases are presently being conducted in Ghana with adults emerged from cocoons produced in Switzerland. Releases started in late 2024 and establishment has not yet been confirmed. It is planned to ship *E. laphygmae* to other countries in Africa and Asia in 2026, for rearing or direct releases.

Fall armyworm predation pressure in cereal agroecosystems – predator diversity, density and associated predation rates and patterns

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A number of *Spodoptera frugiperda*, fall armyworm (FAW) natural enemies have been documented in Africa, but their density and FAW predation rates in cereal agroecosystems is unknown. We assessed the diversity, density and potential FAW predation rates in four cereal agroecosystems (sole maize, sole sorghum, maize-cowpea and sorghum-cowpea intercrops). Twenty plasticine caterpillars were placed on cereal leaf sheaths along field edges and field centres for 72 h to allow for predation. These were assessed for predation marks using an online tool. In addition, FAW and natural enemy counts were recorded from six 2.25 m^2 quadrats in each agroecosystem. Results show significant differences in predation rates among agroecosystems ($p < 0.01$), with higher predation rates in sole maize (51.0 ± 5.85%) than other agroecosystems (26.9–36.0%). Predation mark analyses categorized predators into three groups – invertebrates, mammals and birds, with invertebrates being the most dominant. Fall armyworm density was higher in sole maize (4.1 per m^2) than in other agroecosystems (0.6–1.6 per m^2), whereas ants and carabid beetle densities were higher in the two intercrops than in the sole crops. Spider densities were significantly higher on field edges (0.6 per m^2) than in the middle of the field (0.3 per m^2). Birds' attack marks were concentrated on the head region; invertebrate attacked the body region, whereas mammals randomly attacked the dummies. These findings show that intercropping cereals and cowpeas reduce FAW infestation while increasing natural enemy densities. However, most of the predators recorded were generalists, hence their efficacy against FAW can be ascertained by cafeteria experiments.

Fall Armyworm herbivory in smallholder maize systems: implications for natural enemy activity and habitat management in Southern Africa

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The fall armyworm (*Spodoptera frugiperda*) poses a persistent threat to smallholder maize production across sub-Saharan Africa. Yet, little is known about how its herbivory patterns are shaped by the surrounding landscape and seasonal dynamics. This study investigated the seasonal incidence of fall armyworm-related herbivory across maize fields, edge zones, and adjacent bushveld habitats in semi-arid agroecosystems of Botswana and Namibia. We assessed herbivore pressure using sentinel plants, quantified predator activity using artificial caterpillars, and recorded other ecological functions such as dung removal across two seasons. Results revealed that *S. frugiperda* herbivory peaked significantly in maize fields during the wet season, coinciding with reduced predator activity compared to edge and natural habitats. In contrast, edge habitats supported consistently higher levels of predator presence and ecological multifunctionality. These findings suggest that fall armyworm pressure in smallholder systems is exacerbated by habitat simplification and seasonal predator suppression. We argue that maintaining or restoring natural habitat features at field margins can enhance biological control services and mitigate the impact of key lepidopteran pests in maize-dominated landscapes. This work contributes to ongoing efforts to integrate ecological approaches into sustainable pest management strategies for maize production in African drylands.

Keywords:
Fall armyworm, maize, predator activity, habitat management, smallholder farming, biological control, Botswana, southern Africa.

Biological control strategies for sustainable management of fall armyworm (*Spodoptera frugiperda*) in maize

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The fall armyworm (*Spodoptera frugiperda*) is a highly invasive pest that has caused extensive damage to maize and other staple crops worldwide, threatening food security, particularly in Africa, Asia, and the Americas. Conventional reliance on chemical pesticides has led to resistance development, environmental contamination, and harm to non-target organisms, necessitating the adoption of sustainable biocontrol strategies. Efficacy of various biocontrol agents including entomopathogenic fungi, parasitoids, and predatory insects were tested against fall armyworm under laboratory and field conditions of Jammu regions. Entomopathogenic fungi such as *Beauveria bassiana* and *Metarhizium anisopliae* have demonstrated high efficacy against fall armyworm larvae, with mortality rates of 80–90% at spore concentrations of 1×10^8 spores/ml under laboratory conditions. Field applications have shown 60–75% reduction in larval infestations, particularly when combined with proper formulation and delivery systems. Egg parasitoids, including *Telenomus remus* and *Trichogramma* spp., exhibit 50–90% parasitism rates, effectively suppressing fall armyworm populations before larvae cause significant crop damage. Integrated pest management (IPM) strategies that combine multiple biocontrol agents with semiochemical attractants or habitat manipulation have shown synergistic effects, achieving 85–95% suppression of fall armyworm populations. The combined use of *B. bassiana* and *M. anisopliae* in maize fields has resulted in near-complete larval control, while augmentative releases of *Trichogramma* alongside pheromone traps have reduced infestations by 60–75%. Economic analyses indicate that biocontrol methods can reduce pest management costs by 20–30% compared to synthetic pesticides, while also minimizing ecological risks. The potential of biocontrol as a viable, eco-friendly alternative to chemical pesticides in fall armyworm management.

Chemical strategies for management of fall armyworm (*Spodoptera frugiperda*) in maize

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The rapid spread of fall armyworm (*Spodoptera frugiperda*) has posed unprecedented challenges to maize cultivation in Jammu's agricultural landscape. Recent studies conducted across Jammu's major maize-growing belts reveal critical insights into insecticide efficacy and resistance patterns that are shaping current management strategies. Field assessments demonstrated that new insecticides, particularly chlorantraniliprole from the diamide class, showed 90–95% larval mortality rates. Emamectin benzoate continues to show reliable efficacy (85–90% as compared to control), while spinetoram provides moderate protection of 80–85% suppression. The effectiveness of conventional pyrethroids has declined alarmingly to 50–65% efficacy. The economic impact on farmers of Jammu has been substantial, with current control measures costing ₹3,000–4,000 per acre each season, typically requiring 3–5 insecticide applications during peak infestation periods from July to September. This financial burden, combined with growing resistance concerns, has necessitated the development of more sustainable integrated pest management approaches. Promising results from recent on-farm trials demonstrate that combining pheromone-based monitoring with targeted diamide applications can maintain 85–90% pest control while reducing overall insecticide use by 30–40%. These integrated strategies emphasize careful rotation of insecticide classes, with particular focus on preserving the effectiveness of diamides and spinosyns in high-resistance areas.

Session 6-T 5 - Sustainable management of fall armyworm in smallholder farming systems

Novel mito-nuclear combinations facilitate the global invasion of a major agricultural crop pest

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A fundamental understanding of the underlying mechanisms involved in biological invasions is crucial to developing effective risk assessment and control measures against invasive species. The fall armyworm (FAW), *Spodoptera frugiperda*, is a highly invasive pest that has rapidly spread from its native Americas into much of the Eastern Hemisphere, with a highly homogeneous nuclear genetic background. However, the exact mechanism behind its rapid introduction and propagation remains unclear. Here, we conducted a systematic investigation into the population dynamics of FAW in China from 2019 to 2021, and found that FAW individuals carrying “rice” mitochondria (FAW-mR) were more prevalent (> 98%) than that with “corn” mitochondria (FAW-mC) at the initial stage of the invasion and in newly-occupied non-overwintering areas. Further fitness experiments showed that the two hybrid-strains of FAW exhibit different adaptions in the new environment in China, and this may have been facilitated by amino acid changes in mitochondrial-encoded proteins. FAW-mR used increased energy metabolism, faster wing-beat frequencies and lower wing loadings to drive greater flight performance and subsequent rapid colonization of new habitats. In contrast, FAW-mC individuals adapted with more relaxed mitochondria and shuttled energetics into maternal investment, observed as faster development rate and higher fecundity. The presence of two different mitochondria types within FAW has the potential to significantly expand the range of damage and enhance competitive advantage. Overall, we describe a novel invasion mechanism displayed by the FAW population that facilitated its expansion and establishment in new environments.

Field demonstration of fall armyworm management in Kenya and Ghana

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Fall armyworm (FAW) is the most destructive pest of maize worldwide. Native to the Americas, it invaded Africa in 2016 and China in 2019, often causing total crop loss, particularly in Africa. We conducted on-farm demonstrations in two sites in Kenya (Bungoma and Embu) and two in Ghana (Pampaso and Kpong). At baseline, damage incidence ranged from 73.3% to 93.7% of plants, with larval densities of 95-532 larvae per 100 plants. Six treatments were compared: neem oil by dropping off treated sands, *Bt* by dropping off treated sands, emamectin benzoate by spraying with a knapsack sprayer, emamectin benzoate by dropping off treated sands, chlorantraniliprole by spraying with a knapsack sprayer, chlorantraniliprole by dropping off treated sands were set in Kenya and the chlorantraniliprole was replaced by lambda cyhalothrin in Ghana. An untreated control was included. The number of living larvae and leaf damage level were investigated every seven days. After a planting season investigation, the results in Ghana showed *Bt*-treated with sand and emamectin-benzoate—both spray and dropping off treated sand mix—provided the best control and lowest leaf damage; neem oil showed moderate efficacy, whereas lambda-cyhalothrine was ineffective. In Kenya, emamectin-benzoate and chlorantraniliprole were highly effective; *Bt* was less so. In addition, 5 local Ghanaian and 11 Kenyan maize varieties were screened for natural resistance. The demonstrations offer smallholder farmers clear, side-by-side evidence to guide their FAW management decisions.

Integrating genomics and genome scans for the sustainable management of *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

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Understanding how invasive pests respond to environmental, climatic, and anthropogenic-induced selection processes after their successful population establishment across agricultural landscapes, will be fundamental to the development and implementation of ecologically responsible and sustainable management solutions. The fall armyworm (FAW) *Spodoptera frugiperda* represents a significant pest of maize crop in its native (i.e. North and South Americas) and especially across its recently introduced ranges in Africa, Asia, and Oceania (e.g. Australia). The challenge of developing a sustainable management plan for FAW is further complicated by the genomic diversity in introduced populations due to multiple independent introductions, by the bridgehead effect underpinning their spread, and the co-introduction of the two incipient *S. frugiperda* sister species widely referred to as the corn-preferred and rice-preferred FAW 'strains' (i.e. Sfc and Sfr). Determining the strain identity in introduced populations remained a priority for many impacted countries despite genomic evidence supporting extensive introgression (i.e. hybridisation and backcrossing) between the Sfc and Sfr strains. On-going confusion on the hybrid status of established populations is also exacerbated by inconsistencies relating to genome analysis approaches. In this multi-nation research effort supported by the South Korea Rural Development Administration's (RDA) Asia Food and Agricultural Cooperation Initiative (AFACI) PMP+ project titled "Asia Regional FAW and BPH diagnostics and Monitoring and Surveillance Program", we applied whole genome sequencing approach to interrogate FAW genome signatures of populations collected in 2024 from Sri Lanka, Bangladesh, Bhutan, Cambodia, Lao PDR, Thailand, Vietnam, Indonesia, Philippines, and South Korea, and compared with genome signatures of other invasive FAW populations previously analysed at the onset of the FAW crisis between 2016–2019, to gain an understanding of potential genomic changes that could represent signatures of selection at temporal and spatial scales. We discuss our findings to highlight the importance of integrating the genome scan for the development of sustainable FAW management solutions as the pest continues to spread, establish, and adapt to new habitats. This work highlights the importance of a collective response to threats on food security, plant health, and trade access posed by transboundary plant and crop pests.

Invasion and adaptation: recurrent infestations of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith), on rice in the Philippines

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The fall armyworm (*Spodoptera frugiperda*) is a highly polyphagous invasive pest of global concern, notorious for its significant damage to maize. However, its broad host range poses an emerging threat to other major crops, including rice. In the Philippines, recurrent infestations on rice were documented from 2021 to 2024 in Gonzaga and Santa Ana, Cagayan, following the first report in May 2021. This study investigated the pest's presence and genetic diversity in rice-growing regions. DNA barcoding of larval samples revealed the presence of both C-strain and R-strain of *S. frugiperda* infesting both rice and maize in these ecosystems, indicating a mixture of these two strains. Subsequent surveillance recorded the pest's spread from Region 2 to Region 1 and the Cordillera Administrative Region (CAR), where infestations affected seedlings of hybrid, inbred, and traditional rice varieties at the seedbed stage. To raise awareness of this emerging threat, the CABI centre based in Malaysia and DA-PhilRice conducted webinars providing information on the biology, ecology, and management of *S. frugiperda* for researchers, agricultural extension workers, and academic institutions. Field assessments also identified dominant weed species that may serve as alternate hosts, and two parasitoid species were newly documented, offering potential for biological control. Current research efforts focus on evaluating indigenous fungal entomopathogens isolated from infected larvae, optimizing cultural practices, and surveying natural enemies to develop location-specific, nature-based management strategies. These findings represent a critical update on the pest's host shift and distribution, highlighting the urgent need for location-specific, nature-based solutions for managing *S. frugiperda* in Philippine rice ecosystems.

Collaborative action against fall armyworm in Southeast Asia: progress, challenges, and future directions

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The fall armyworm (FAW) emerged as a major invasive pest in Southeast Asia in late 2018, spreading rapidly to all maize-growing countries by 2020. The pest posed a severe threat to food security, livelihoods, and regional trade, given the reliance of nearly 100 million smallholder farmers on maize and other staple crops. Recognising the urgency of coordinated action, ASEAN countries launched a comprehensive response combining national strategies with collective regional initiatives. The ASEAN FAW Action Plan, endorsed in 2020, became a cornerstone of collaboration. It established seven thematic programmes spanning monitoring and surveillance, biocontrol, resistance management, drones and digital IPM, farmer training, gender empowerment, and regional communication. In parallel, national governments developed guidelines, farmer training programmes, and demonstration projects. Research institutions contributed critical innovations, including genomic characterisation of FAW populations, pheromone monitoring technologies, and biocontrol trials. Outcomes show both progress and ongoing challenges. Reported crop losses declined significantly after the initial outbreaks, reflecting improved farmer knowledge, extension services, and possible natural enemy adaptation. However, reliance on chemical pesticides remains widespread, raising health and environmental concerns and driving resistance risks. Localised outbreaks, weak monitoring systems, and uneven farmer access to resources highlight the need for sustained investment. The experience also underscores the role of socio-economic and behavioural factors, including gender dynamics and affordability, in shaping long-term IPM adoption. Key lessons include the value of multi-stakeholder collaboration to address transboundary pest threats, the importance of embedding science-based solutions into policy and practice, and the need for harmonised monitoring systems to strengthen preparedness. The Action Plan offers a transferable model for addressing other emerging invasive pests. While progress has been achieved, sustaining gains requires continued investment in IPM, regulatory alignment, farmer-centred training, and stronger regional frameworks. Lessons are now being incorporated into a second phase, extending to other priority pests and diseases. Building on these foundations ASEAN is better positioned to respond to future invasive threats, strengthening the resilience of agriculture and food systems in the region.

Changing practices favour cutworms and increase their pest status in maize and soybean in South Africa

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The increasing pest status of the common cutworm, *Agrotis segetum* (Denis & Schiffermueller) (Lepidoptera: Noctuidae) is a major threat to maize and soybean crops in South Africa. Low seedling stand caused by cutworm damage shortly after emergence forces farmers to replant and numerous complaints have been raised regarding the ineffectiveness of chemical insecticides. This pest was previously well-managed through cultivation practices before planting. Cutworm pest status is closely linked to larval density within fields at the time of planting. Population size, in turn, is influenced by rainfall, temperature, weed presence, and moth activity. A critical factor determining population size is the survival of larvae through winter. Cutworms are polyphagous and commonly associated with a variety of weed species, particularly those with rosette-forming leaves that lie flat on the soil surface. The adoption of reduced- or no-till systems and the chemical burndown of weeds prior to planting have inadvertently created ideal conditions for cutworm moths to lay eggs and for larvae to overwinter successfully. Although the aerial parts of large weeds are killed during burndown, basal leaves often remain green, and root systems persist underground, providing continued sustenance to larvae. In the absence of tillage and effective weed management, weedy host plants remain on fields until planting and overwintering larvae are not destroyed. The current high pest status and increased economic impacts of this pest appears to be driven more by shifts in weed management and cultivation practices than by insecticide resistance.

Session 7-T 2 - Integrated pest management tools and packages for maize pests

Climate change threatens the suitability of *Telenomus remus* for fall armyworm biological control

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For the parasitoid to provide effective ecosystem services, it should be able to survive and coexist within the same ecological niches with its host. There is limited information regarding the potential responses of *Telenomus remus* to thermal changes. In the context of the changing climate environments this is key to understand its overall environmental fitness in relation to its host. We investigated the effects of short-term (2 h) and long-term (6 h) acclimation pretreatment of *T. remus* adults and *S. frugiperda* eggs to high and low temperatures (18 and 32°C) in comparison to the control (28°C). *Telenomus remus* thermal fitness [(critical thermal maxima (CT_{max}), heat knockdown time and critical thermal minima (CT_{min})], parasitism rates and adult emergence was determined. Pre-treated *S. frugiperda* eggs were assessed for hatchability under the control conditions. Acclimation at low (18°C) and high (32°C) temperatures significantly reduced and increased heat tolerance, respectively. Both temperatures, however, reduced cold tolerance. The parasitoid thermal tolerance polygons following acclimation pretreatment showed significant heat- but not cold-tolerance gains. Fall armyworm eggs short-term acclimated to 32°C had significantly higher but comparable hatchability to the control treatment. Similarly, parasitism and adult emergence rates were significantly lower following long-term acclimation of host eggs and the parasitoid to 32°C. These findings suggest that high temperatures may decouple *T. remus*-fall armyworm ecological relationship, threatening its success in warming regions. These findings suggest valuable insights into the environmental resilience and suitability of *T. remus* as a biological control agent across different climates or geographies.

Session 7-T 3 – Integrated pest management tools and packages for maize pests

Combination use of entomopathogenic nematodes and botanical spray oil for the control of fall armyworm in maize

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Entomopathogenic nematodes (EPNs) demonstrate significant potential for controlling fall armyworm (*Spodoptera frugiperda*) in maize fields. However, their efficacy in practical applications is often inconsistent due to abiotic environmental factors and application challenges. Synergists offer a promising solution to enhance control efficiency. This study confirmed the compatibility between EPNs and botanical spray oils and evaluated their synergistic control effect against fall armyworm larvae under laboratory and field conditions. Laboratory results showed that combining *Steinernema carpocapsae* All with botanical spray oil T80 significantly increased larval mortality of the fall armyworm larvae. In field trials, the mixture of *S. carpocapsae* All and botanical spray oil T80 applied twice during the maize growth period provide crop protection equivalent to conventional chemical pesticides in both sweet corn and waxy corn. Notably, plant damage rates were significantly lower than those in water-treated controls. These findings establish a theoretical foundation and practical strategy for the integrated use of EPNs and botanical oils in fall armyworm management.

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Session 7-T 4 - Integrated pest management tools and packages for maize pests

A network of high-resolution vertical-looking radar for automatic monitoring of high-flying insects over a wide area

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Continuous monitoring of insect pests plays a crucial role in developing effective pest management strategies and implementing successful control measures. Recently developed smart traps, light-traps, pheromone traps and baited traps incorporated with AI (Artificial Technology) and IoT (Internet of Thing) technologies, have significantly reduced the labor required for monitoring traps and improved the precision of pest management strategies. However, these traps are less effective for detecting high-altitude migrants. The newly developed high-resolution vertical-looking radar (VLR) can detect an individual insect of 8 mg up to 2000 m, and produce detailed information on target identification (size, shape, wingbeat frequency) and flight behavior (flight time, height, track speed, track direction, body alignment, and climb rate) of the insects. The VLR-inferred tracking of small insects could also provide accurate estimates of wind velocity. Such VLR has been used to quantify the annual pattern of nocturnal insect migration above the densely populated agricultural lands of East Asian Insect Flyway. A total of ~9.3 trillion nocturnal insect migrants (15,000 tons of biomass), predominantly Lepidoptera, Hemiptera, and Diptera pests, fly at heights up to 1 km above the 600 km-wide region of East China every year. The transport of insect biomass is considerably greater above East China than above the UK. Larger migrants (> 10 mg) exhibited seasonal reversal of movement directions, comprising northward expansion during spring and summer, followed by southward movements during fall. Spring and summer migrations were strongest when the wind had a northward component, while in fall, stronger movements occurred on winds that allowed movement with a southward component. A network of high-resolution VLRs has been established for automatic long-term monitoring migrant insect pests through EAIF and preliminary results on beet armyworm *Spodoptera exigua* exhibited potential to be used as a powerful tool for automatic monitoring of migrant insect pests over a wide area. This may provide surveillance information for insect pest control in this region, specifically for pest control using both traditional biological control and emerging technologies targeting adult insect pest, such as attract-and-Kill, push-pull or mating disruption, may offer a more efficient, precision and environment friendly way to control insect pests.

Session 7-T 5 - Integrated pest management tools and packages for maize pests

Developing an IPM toolbox against fall armyworm in Europe

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After its invasion into Asia, Africa and Australia, the fall armyworm (*Spodoptera frugiperda*) has recently started to invade mainland Europe. It has been officially recorded from Greece in 2023 and Romania in 2024. It is expected to soon invade further regions of the warm temperate climates of Europe. It is also expected to become a migratory pest for other slightly cooler European maize production regions, a pattern as known from North America and East Asia. This has led to concerns regarding situations without satisfactory technical solutions, potential yield losses, as well as a sudden large influx of pesticides. Therefore, a European Union-financed research and development project has started in June 2025 and is pooling forces from different stakeholders to help preparing Europe for this pest. The project will also develop a toolbox of integrated pest management of fall armyworm suitable for European farmers. We will evaluate and rank existing and new developed IPM tools including e.g. cost-effectiveness, efficacy, safety, availability, practicability, benefits, reliability for stakeholders and environmental impact. Then, together with key stakeholders and their feedback, we will develop an IPM toolbox for managing established or transient fall armyworm populations. This toolbox will also utilize the IOBC green and yellow list systems of IPM to compile fall armyworm Pest Management Decision Guide(s) for European farmers and advisers with the most practical, economical, safe, and effective pest management solutions, including on-farm monitoring and decision-making that can be applied within the EU's agronomic and socio-economic context. It will also encompass biological and other green pest management options. The farmers' acceptability of the solutions in the toolbox will be identified through panel meetings with maize producers. We herewith present a set of possible IPM tools against fall armyworm and seek feedback from the global community. Ultimately, we aim to empower European agricultural actors, such as farmers, advisors, technicians, industry and to enhance their preparedness for fall armyworm and to minimize the economic, environmental and social impact.

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Unraveling patterns in the Corn Belt: impacts of connectivity in corn agroecosystems on a common pest of corn (*Agrotis ipsilon*)

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Insect pest densities respond to the composition and arrangement of crop and non-crop habitats over the landscape. Managing the spatial distribution and connectivity of these habitats could be useful as a method of reducing pest pressure. In this study we investigate the relationship between landscape connectivity and pest densities in the corn growing areas of southern Wisconsin. We analyzed ten counties across three years across the southern half of the state using five common metrics of connectivity. We analyzed the relationship between the proportion of county level corn cover and pest population numbers in ten counties across three years across the southern half of Wisconsin. This was then compared to the relationship between connectivity of farms and the success of pests in the same area. The relationship between connectivity and pest populations was further compared to baseline figures of landscape composition. There was some indication that connectivity may have some significance in contributing towards the success of pests at the landscape level. Component size was also correlated with pest pressure. There was significant variability in the degree of connectivity of agricultural areas in Wisconsin. Accounting for the significance of connectivity could be useful when designing management strategies for pests.

Graphene oxide enhances the dual role of *Beauveria bassiana* in biocontrol of the Asian corn borer and promotion of the maize seedling growth under field conditions

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The burgeoning demand for sustainable pest control has driven the integration of nanotechnology with biocontrol agents. This study explores the use of graphene oxide (GO) as a nanocarrier to enhance the efficacy of *Beauveria bassiana* (Bb) against *Ostrinia furnacalis* (Asian corn borer, ACB), while concurrently enhancing the maize growth. GO-Bb nanocomposite at a concentration ratio of 4:1 demonstrated remarkable improvements in the thermal stability and ultraviolet resilience of Bb. At a concentration of 20 μg/ml, 61.4% spore germination rate was observed at 40°C. Furthermore, the germination rate experienced a diminution of less than 20–30% following exposure to ultraviolet radiation for 12 and 24 h, respectively. The colonization rate of Bb in maize increased to 100% at 14- and 83.33% at 21-days after emergence. Field experiments revealed that GO-Bb nanocomposite significantly reduced the ACB damage on maize plants 28 days after germination. Uptake of the GO-Bb nanocomposite activated phytohormone signaling pathways and boosted insect-resistance. Weighted gene coexpression network analysis of DEG revealed the upregulation of an abscisic acid-responsive gene, ABR1, following GO-Bb treatment at 12h post ACB infestation. ACB damage over 24 hours can lead to higher concentrations of DIMBOA-Glc, HDMBOA-Glc, MBOA, HM2BOA-Glc, and DIM2BOA-Glc in the GO-Bb treatment than CK and Bb. Additionally, the GO-Bb treatment significantly upregulated the gene expression of BX10, a marker gene associated with BX-regulated defense, even in the absence of ACB damage. These findings underscore the dual benefits of GO-Bb nanocomposite. It has the capability to integrate pest management with the promotion of plant growth synergistically. By enhancing Bb's pathogenicity and activating maize's defense pathways, it offers a sustainable alternative for integrated pest management. Future research should explore its extensive applications within crop protection and sustainable agricultural.

Threats of corn production in Indonesia due to *Ostrinia furnacalis* and *Spodoptera frugiperda*

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Corn is the target of self-sufficiency in Indonesia and the harvest has been approximately 2.5 million ha/year. Two major corn insect pests are the Asian corn borer (ACB, *Ostrinia furnacalis*) and the fall armyworm (FAW, *Spodoptera frugiperda*), and these pests are present in all major corn production provinces. ACB mainly damage corn during the reproductive stage with 50% of plants infested and an average of 1.5 holes per plant. Under heavy infestation, the damage increased to 95% averaging 3.0 holes per plant. FAW may attack corn at the early until the reproductive stages. The plants may recover when they were defoliated during the vegetative stage. FAW attacking on the stem and cob cause serious yield loss and one observation showed almost complete yield losses. Management of these pests mostly relies on the use of synthetic insecticides. However, the behavior and biology of these insects pose some challenges that reduce the effectiveness of insecticide when they are not applied properly. The *Bacillus thuringiensis* (*Bt*) corn expressing Cry1Ab has been planted by farmers since 2023 which provide a good control for ACB. Additionally natural enemies particularly eggs parasitoids are essential element of the ecosystem services which provide approximately 40% mortality rate of these pests. Considering the potential damages and the existing control measures, pest management should be formulated based on integrated pest management (IPM) principles to minimize the risks associated with the pests and the applied control measures while ensuring high productivity.

Integrated pest management (IPM) for fall armyworm (FAW, *Spodoptera frugiperda*) control of grain corn in Malaysia

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Fall armyworm (FAW) (*Spodoptera frugiperda*) is an invasive pest of grain corn in Malaysia, causing crop damage and yield loss in 2019 and 2020. Therefore, an integrated pest management (IPM) approach for FAW control was developed and evaluated in one planting season using P4546 grain corn variety at Chuping, Perlis, Malaysia in 2021/2022. The IPM approach mainly involved pheromone trap application at 14 days before planting as an early monitoring tool for FAW within the area. For the field control of FAW, *Bacillus thuringiensis*-based bioinsecticide and chemical insecticides, emamectin benzoate and chlorantraniliprole were applied alternately at different stages of plant growth (7–49 days after planting) based on FAW infestation levels. As a comparison, the FAW control in non-IPM plot was based on farmer's common practice. The incidence and severity of FAW infestation and beneficial insect populations were measured weekly for eight weeks after planting in both IPM and non-IPM (control) plots. Results showed no significant difference in mean incidence of FAW between IPM and the control. However, the mean severity of FAW infestation in IPM (4.47%) was significantly lower than that of the control (5.19%). No significant difference was found in the population of beneficial insects between IPM plot and the control plot. Meanwhile, the yield was higher for IPM (6.508 t/ha) compared to the control (6.212 t/ha). In conclusion, the IPM approach effectively controlled FAW in grain corn without causing severe damage and yield loss. It is suggested that more than one planting season is required to determine noticeable effects of IPM on insect population in the field and crop yield. This is an interim IPM for FAW of grain corn. Further improvement is needed, such as the application of biological control agents as a control measure.

Keywords: Fall armyworm, grain corn, integrated pest management.

Session 8-T 1 - Free themes

Biogeographic risk mapping of fall armyworm (*Spodoptera frugiperda*) in Iligan city based on farm level and climatic data

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The invasive and highly destructive corn pest, fall armyworm (*Spodoptera frugiperda* J.E. Smith), has rapidly spread across the Philippines since its first detection in 2019, resulting in significant yield losses and food insecurity. Persistent infestations have been reported in Iligan City, Lanao del Norte, a key corn-producing area in Northern Mindanao, from July 2020 up until recently in May 2025. This study presents the first biogeographic risk mapping of *S. frugiperda* in Iligan City by integrating farm-level infestation records and seasonal climatic data collected from 22 infested barangays out of 44 total during both dry and wet seasons. Plotting point density in ArcGIS v.10.8 revealed high infestation rates in most areas, with Digkilaan consistently recording the highest number of affected corn farms. The pest distribution is influenced by elevation, proximity to rivers, seasonal climate variations, and the combined effects of biological, ecological, and socio-economic factors. Interestingly, the resurgence of infestation in 2024 concurred with El Niño-related drought, and dormancy during 2021–2022 was attributed to COVID-19 restrictions. Drier months exacerbated damage in central and west barangays, while wet seasons transferred risks to southern sectors. Computed risk scores identified Digkilaan, Bunawan, Ditucalan, Dulag, Kabacsanan, Mandulog, Pugaan, Rogongon, Sta. Elena and Tomas Cabili as persistent high-risk zones vulnerable to *S. frugiperda* attacks all year round. This study supports the development of localized, climate-responsive early warning systems and targeted surveillance planning to reduce crop losses and enhance food security in the region

Session 8-T 2 - Free themes

Landscape of structural variants reveals insights for local adaptations in the Asian corn borer

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Capturing the genetic diversity of different wild populations is crucial for unraveling the mechanisms of adaptation and establishing links between genome evolution and local adaptation. Asian corn borer (ACB) moth has undergone natural selection during its adaptative evolution. However, structural variants (SVs) that play significant roles in these adaptation processes have not been previously identified. Here, we constructed a muti-assembly graph pangenome and newly sequenced 509 individuals to highlight the importance of SVs in local adaptation. We found that the graph pangenome contained 176.60 Mb (~37.33%) of novel sequences. More than 50% of SVs were derived from transposable elements. Subsequently, we performed an analysis of expression quantitative trait loci (eQTLs) to explore the impact of SVs on gene expression regulation. We found that distant-eQTLs were the most predominant type of eQTL identified compared to local-eQTLs. We observed that local-eQTLs exhibited significant associations with gene expression compared to distant-eQTLs. Notably, through quantitative trait locus (QTL) mapping analysis, we identified the FTZ-F1 gene as a potential candidate gene associated with the traits of larval development rate using information derived from SVs. A 225 bp insertion in the South population was observed to significantly reduce the promoter's strength in a luciferase assay across various geographical populations. By integrating the graph pangenome and identifying SVs, we have established a valuable genomic resource for studying the effects of SVs on local adaptation in pests. Moreover, this approach highlights the genetic basis of adaptive traits observed in wild populations, therefore, facilitating accelerated pest management strategies under different climatic conditions.

ABSTRACTS
POSTER
PRESENTATIONS

Poster 01
Session 1 - Recent research and extension efforts in North America to delay Bt resistance in maize pests

Cross-resistance between Cry1Ab toxin and abamectin in *Ostrinia furnacalis*

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The Asian corn borer, *Ostrinia furnacalis*, is the most significant economic insect pest of maize in East Asia and Australia. The deployment of transgenic maize expressing *Bacillus thuringiensis* (*Bt*) toxins has been a key strategy for managing *O. furnacalis*. However, cross-resistance between *Bt* and other insecticides has been reported. For example, Cry1F-resistant strains of *Spodoptera frugiperda* demonstrated cross-resistance to deltamethrin and chlorpyrifos. Since 2023, multiple genetically modified maize varieties have been approved in China. Investigating the resistance mechanisms of *O. furnacalis* to *Bt* toxins, particularly evaluating potential cross-resistance risks with conventional chemical insecticides, holds practical significance. In this study, a strain of *O. furnacalis* selected with Cry1Ab toxin incorporated into artificial diet developed 43-fold resistance to Cry1Ab after 38 generations of selection. Subsequently, toxicity of seven insecticides against this resistant strain and the susceptible strain were evaluated. Deltamethrin, cyhalothrin, thiamethoxam, emamectin benzoate, indoxacarb, and tetrachlorantraniliprole showed no significantly different toxicity between resistant and susceptible strains. However, the resistant strain exhibited a 7.15-fold LC50 for abamectin compared to susceptible strain, suggesting potential cross-resistance between Cry1Ab and abamectin. Biochemical assays demonstrated that glutathione S-transferase (GST) activities were significantly higher in Cry1Ab-resistant strain, while mixed-functional oxidase (MFO) and carboxylesterase (CarE) activities remained unchanged. Synergism experiments utilizing diethyl maleate, a GST inhibitor, resulted in significant toxicity enhancement, reducing abamectin LC50 values by 29.92% and 43.17% in susceptible and resistant strains, respectively. Transcriptional profiling identified that the expression levels of GSTe1, GSTs3, GSTd2 and GSTd4 were significantly upregulated in the resistant strain, while the expression levels of GSTe3, GSTz and GSTt4 were significantly downregulated. These findings underscore the critical role of GST in mediating Cry1Ab-abamectin cross-resistance in *O. furnacalis*, though the specific mechanism requires in-depth investigation. This study highlights the potential for cross-resistance development between *Bt* toxins and conventional insecticides, emphasizing the need for comprehensive resistance monitoring and integrated pest management strategies.

Poster 02
Session 2 - Pre-breeding and breeding for resistance to key lepidopteran pests, improved yield and yield-related traits

Characterization of 25 Zambian maize landraces for resistance to key lepidopteran pests

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Maize (*Zea mays*) is a leading cereal worldwide and an important staple crop in sub-Saharan Africa (SSA). In Zambia, maize is cultivated mostly by smallholder farmers with average yields between 1.4 to 3 t ha^{-1}. An estimated 1.6 million maize small holder farmers grapple with significant biotic challenges that are mostly associated with lepidopteran insect pests. This study aims to screen 25 Zambian-adapted maize genotypes for resistance to key lepidopteran pests affecting maize production. Field trials consisting of the 25 maize landraces were planted in randomized complete block design at the Zambia Research and Development Centre (ZRDC) in Chongwe district. Under natural pest infestation conditions, the genoptyes will be observed for leaf and cob damage symptoms associated with *Buseola fusca*, *Sesamia calamistis*, *Chilo partellus* and *Spodoptera frugiperda*. In addition to pest related data, a farmer survey will be conducted to determine the key attributes desired by farmers in a maize variety to be incorporated during genotype evaluation. The data will be analyzed using GENSTAT and SPSS analysis software packages to identify superior genotypes for further improvement. Information generated from this pre-breeding study will provide a basis for demand-led breeding of maize with lepidopteran insect resistance and farmer-preferred traits in Zambia.

Poster 03
Session 3 - Bridging research and practice: IPM for piercing-sucking insects in maize systems

Understanding pheromone traps for monitoring stink bug populations

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Stink bugs (Hemiptera: Pentatomidae) are important pests in the southern US and are challenging to control in many crops. From 2020 to 2024, these insects have caused an annual yield loss of approximately 7.17 million bushels in corn and $300 million in soybean losses and costs. Information on indirect monitoring systems could support current field-based direct scouting techniques. Our research goals were to determine the trap that captured most stink bug species and the soybean stage that reached the threshold for the species we targeted. Using field as a replication, we placed seven stink bug pheromone traps (delta, black pyramid, yellow pyramid, and blue, clear, yellow, and white sticky cards) in 34 soybean fields from August to December in 2023 and 2024. We used two types of pheromone lures that targeted different species of stink bugs. Every two weeks, we checked the traps and counted the total number of stink bugs; we also identified stink bug species and replaced the pheromone lure or trap if needed. In addition, we conducted biweekly scouting with 100 sweeps positioned in the field at 15-row intervals from the traps. We recorded the total number of stink bugs from both the traps and the sweep net. Stink bug numbers varied depending on the pheromone trap and soybean stage. By evaluating pheromone traps and identifying key soybean stages of stink bug abundance, the study offers an alternative to time-consuming sweep net sampling. These findings can potentially be applied to monitoring pest populations in other crop systems.

Poster 04
Session 5 - Progresses in biological control of fall armyworm worldwide

Susceptibility of *Spodoptera frugiperda* to commercial entomopathogenic fungi formulations in South Africa

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The fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is an important pest globally, causing substantial crop losses, particularly in maize. The favourable climate in sub-Saharan Africa supports the proliferation of this highly adaptable pest. Chemical control using synthetic insecticides remains the most common approach for managing fall armyworm infestations. However, due to the pest's ability to rapidly evolve insecticide resistance, relying solely on chemical control is neither a sustainable nor a long-term solution. As a result, biological control with entomopathogenic fungi is gaining prominence as a key component of integrated pest management strategies. While numerous laboratory studies have demonstrated the effectiveness of entomopathogenic fungal isolates against various life stages of this pest, few have evaluated the efficacy of commercially available fungal-based biopesticides. The objective of this study was, therefore, to assess the potential of two *Beauveria bassiana* (Balsamo-Crivelli) Vuillemin (Hypocreales: Cordycipitaceae) and two *Metarhizium anisopliae* (Metschnikoff) Sorokin (Hypocreales: Clavicipitaceae) based commercial biopesticides registered in South Africa against other pests, for their efficacy against *S. frugiperda*. The efficacy of these biopesticide formulations were evaluated against *S. frugiperda* larvae and prepupae as well as on moth emergence and fecundity and longevity. Second- and sixth-instar larvae were evaluated and found not to be susceptible to these biopesticides. Moth emergence, fecundity, and longevity were also not significantly affected. However, prepupae were susceptible to both *Metarhizium* formulations, with *M. anisopliae* ICIPE 78 resulting in the highest mortality (56.7%). This biopesticide holds potential for the management of *S. frugiperda* when applied to the soil for the control of pupating larvae.

Poster 05
Session 5 - Progresses in biological control of fall armyworm worldwide

Persistence of entomopathogenic nematodes after above-ground application indifferent formulations onto maize plants

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The invasion of the fall armyworm (*Spodoptera frugiperda*) into Africa and Asia has increased the use of insecticides on maize. Similar problems are expected in Europe due to the recent arrival of the pest on the continent. Less harmful pest management approaches are urgently needed. Entomopathogenic nematodes have shown promising results when correctly formulated and applied as spot treatments into the leaf whorls where the armyworms are feeding and causing damage. These formulations aim to protect the nematodes from environmental stress and to prevent them from flowing down the maize plant. To better understand how certain formulations could affect the movement of applied nematodes on a maize plant, we conducted several series of nematode application experiments on sets of single vegetative maize plants in the hot and dry summer climate of Hungary, which is unfavorable for nematodes. Eight different formulations were tested in at least 2 doses, including oils, surfactants, gels and thickeners, and UV protectants. A volume of 2 ml formulation containing 2000 nematodes was pipetted directly into the whorl of each plant. Nematodes were recovered 1 hour, and 1, 7, and 14 days after treatment by cutting pieces of the maize plant at different levels, washing them in water, letting them sediment and then counting them. Regardless of the formulation, most nematodes were recovered up to 1 day after treatment. Some nematodes were still recovered from the maize plants after 7 days and few nematodes after 14 days with the best results seen for different carboxy methyl cellulose -gel formulations with or without the UV protectant TiO_2, the UV protectant canola oil, the nematode dormancy agent glycerol, and natrium alginate gels. We provide further details on the suitability of each formulation with regard to protecting and keeping nematodes in the leaf whorls of maize to more effectively control this serious maize pest.

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Poster 06
Session 5 - Progresses in biological control of fall armyworm worldwide

Potential of *Metarhizium anisopliae* for sustainable management of *Spodoptera* spp. in maize

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Spodoptera frugiperda (fall armyworm, FAW) and *Spodoptera litura* are devastating maize pests in Malaysia, causing severe yield losses and threatening food security. With the urgent need for sustainable alternatives to chemical pesticides, entomopathogenic fungi (EPF) such as *Metarhizium* spp. offer promising solutions. This study screened 28 local *Metarhizium* strains for virulence against FAW and *S. litura* larvae and pupae, and assessed the soil application potential of top-performing isolates. Pathogenicity against third-instar FAW larvae was evaluated via the dip technique, while soil trials tested efficacy during natural burrowing and pupation. Three isolates namely HREF6, HREF27, and HREF28 caused > 80% larval mortality. In soil, HREF28 achieved 93.3% FAW pupal mortality, outperforming HREF27 (66.7%) and HREF6 (56.7%), with only 10.0% in the control. At 1 × 10^9 spores/m^2, HREF28 induced > 90% FAW pupal mortality and 83.3% in *S. litura*. These findings position HREF28 as a potent, soil-persistent EPF with strong potential for development into a formulation-ready biocontrol agent for sustainable maize pest management.

Poster 07
Session 7 - Integrated pest management tools and packages for maize pests

The effectiveness of commercial pheromone lures for monitoring fall armyworm (FAW) in Malaysia

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The fall armyworm (FAW) is an invasive species that has caused a significant loss of commercial crops worldwide. In Malaysia, fall armyworm was reported in September 2019 with 100% incidence on maize plantations in Changlun, Kedah. Following the reports, the Malaysian Agricultural Research and Development Institute (MARDI), Department of Agriculture Malaysia (DOA), and CAB International (CABI) conducted joint research in developing an Integrated Pest management (IPM) program for managing FAW in Malaysia. One of the components of this program was to identify potential commercial pheromone lures for FAW. Three different pheromone formulations imported from India, the USA, and Costa Rica were evaluated in the laboratory (choice assay) and the field. The lure from the USA attracts more males compared to the lure from Costa Rica in the choice assay. The field study indicated that the lure from Costa Rica attracted significantly more males, followed by USA and India. Therefore, pheromone lures manufactured in Costa Rica have the potential to be implemented in the IPM program for FAW in Malaysia.

Poster 08
Session 7 - Integrated pest management tools and packages for maize pests

Evaluating insecticidal and repellent effects of botanical compounds against adult western corn rootworm (*Diabrotica virgifera virgifera*)

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The western corn rootworm (*Diabrotica virgifera virgifera*, Chrysomelidae) is a major pest of maize in Europe and North America, where resistance to some insecticides and regulatory restrictions have curtailed chemical management options. Botanical insecticides, which are typically characterized by rapid degradation and multimodal action are promising alternatives. This study investigates botanicals delivered through a novel natural-zeolite-based Lithos Micro Dispenser Technology (LMD) for contact toxicity, feeding repellency, and formulation performance against adult *D. v. virgifera*. We conducted a 4-phase investigation under laboratory conditions on LMD-formulated neem that contains azadirachtin, pyrethrin, orange oil that contains d-limonene, and cinnamaldehyde through (1) contact mode of activity, (2) ingestion mode of activity, (3) feeding repellencies, and to compare (4) LMD-formulated pyrethrum with a commercial pyrethrin.
(1) Indirect contact, residue bioassays with treated glass vials and then added beetles revealed that pyrethrin, neem, orange oil and the positive control alpha cypermethrin kill adults comparably fast within 4 h. A higher dose of orange oil was needed to achieve a comparable mortality. Cinnamaldehyde and the formulation did not result in any mortality. Pyrethrin induced most pronounced sublethal effects. (2) Diet core-treatment overlay bioassays in 6-well plates revealed that pyrethrin and neem are also active in the case of ingestion, but orange oil, cinnamaldehyde and LMD are not, and that (3) pyrethrin and neem have some feeding repellency, but other treatments did not. (4) Indirect contact, residue bioassays revealed that pyrethrin in a commercial formulation and in the novel LMD show comparable activity against the beetles from 2 to 24 h exposure as well as 7- or 14-days following treatment. Both reached a comparable maximum mortality of roughly 70% within 24 h at a low dose of 100 ug/ml and showed comparable decreases of effects with time.
These results suggest the need for field trials to optimize application methods, to assess needs of UV protectants, to evaluate non-target safety, and to support the registration of an LMD-based botanical product for integrated rootworm management.

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Poster 09
Session 8 Free themes

Doctor of Plant Medicine: preparing professionals to address global plant health challenges

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The Doctor of Plant Medicine (DPM) program is an interdisciplinary doctoral degree launched in 1999 by the College of Agricultural and Life Sciences at the University of Florida. The DPM Program provides specialized doctoral education that assists future plant health professionals in effectively addressing diverse plant health challenges globally.

This comprehensive, four-year post-baccalaureate program requires students to complete 100 credits of graduate coursework in plant and soil science, horticulture, entomology, nematology, and plant pathology. While a dissertation is not required, students complete two internships with at least one research-focused internship if the student has not completed a thesis-based Master's degree. This practical internship component distinguishes the DPM from traditional graduate programs, giving students real-world experience before beginning their careers.

DPM graduates pursue careers as diagnosticians, crop consultants, plant inspectors, survey specialists, regulatory scientists, extension specialists, and applied researchers. Moreover, the current DPM students make substantial contributions to agricultural safety and pest management in Florida. The individuals engage in applied IPM research, actively spread knowledge through outreach initiatives, and contribute to extension programs.

The DPM program offers a comprehensive and innovative approach to pest management, focusing on experiential learning and practical expertise. Alumni contributions are vital to agricultural safety in Florida by ensuring the long-term sustainability of crop protection. The program's comprehensive approach—combining applied research, outreach, and extension—equips professionals with the skills to address global plant health challenges while supporting the long-term sustainability of crop production.

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