Global Forum on Biological Control and Training Workshop on Biological Control

Nairobi, Kenya 26-30 June 2023

Basic and Concept on microbial control – potential for FAW management

Komivi S. Akutse - kakutse@icipe.org

Co-organized by

Food and Agriculture Organization of the United Nations

icipe

Supported by

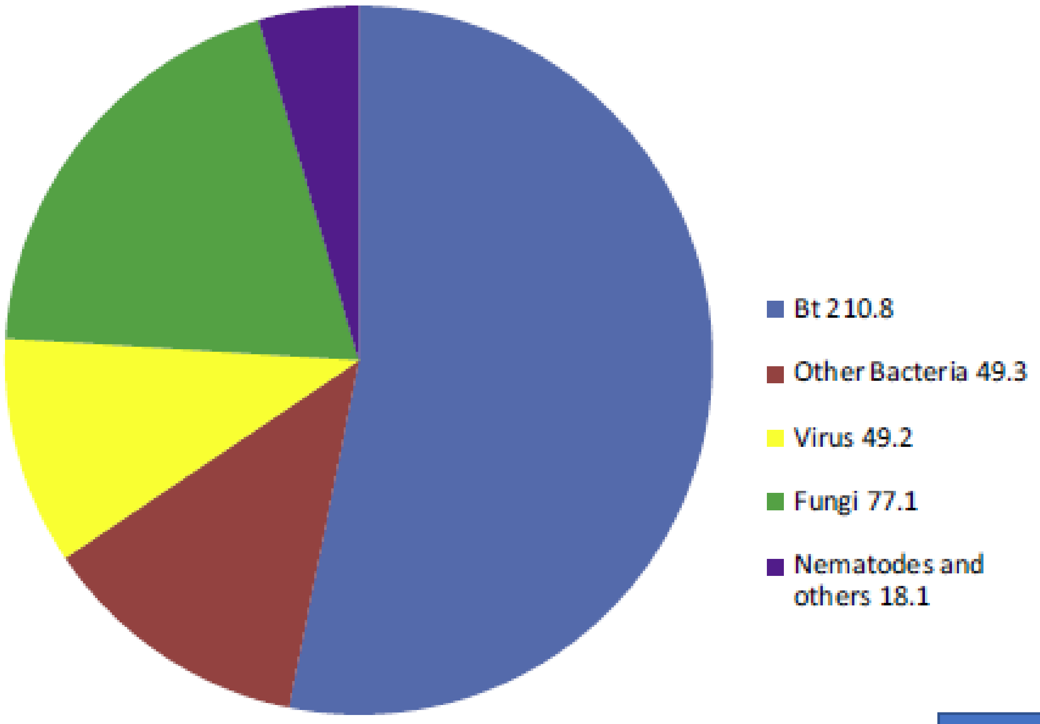
EUROPEAN UNION

USAID FROM THE AMERICAN PEOPLE

german cooperation DEUTSCHE ZUSAMMENARBEIT

Implemented by giz

Estimated world biopesticide sales & alternative to pesticides

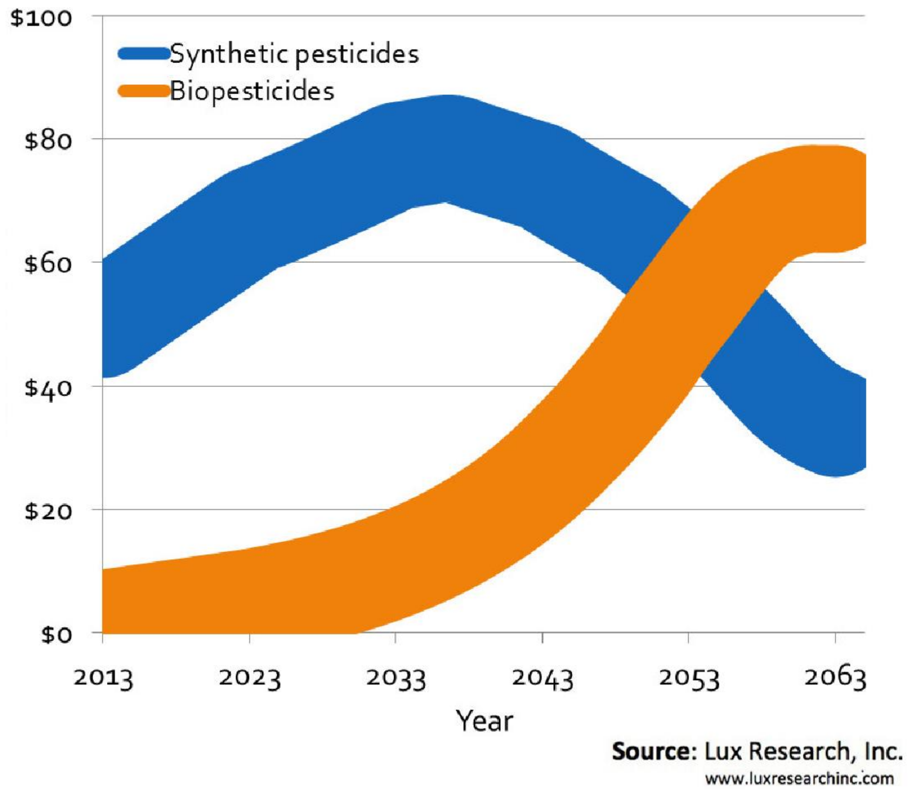


$404.5 M - *in 2010*

- Global chemical market is projected to grow from **$70.24 bn** in 2019 to **$101.64 bn** in 2026 ~ **5.42%**

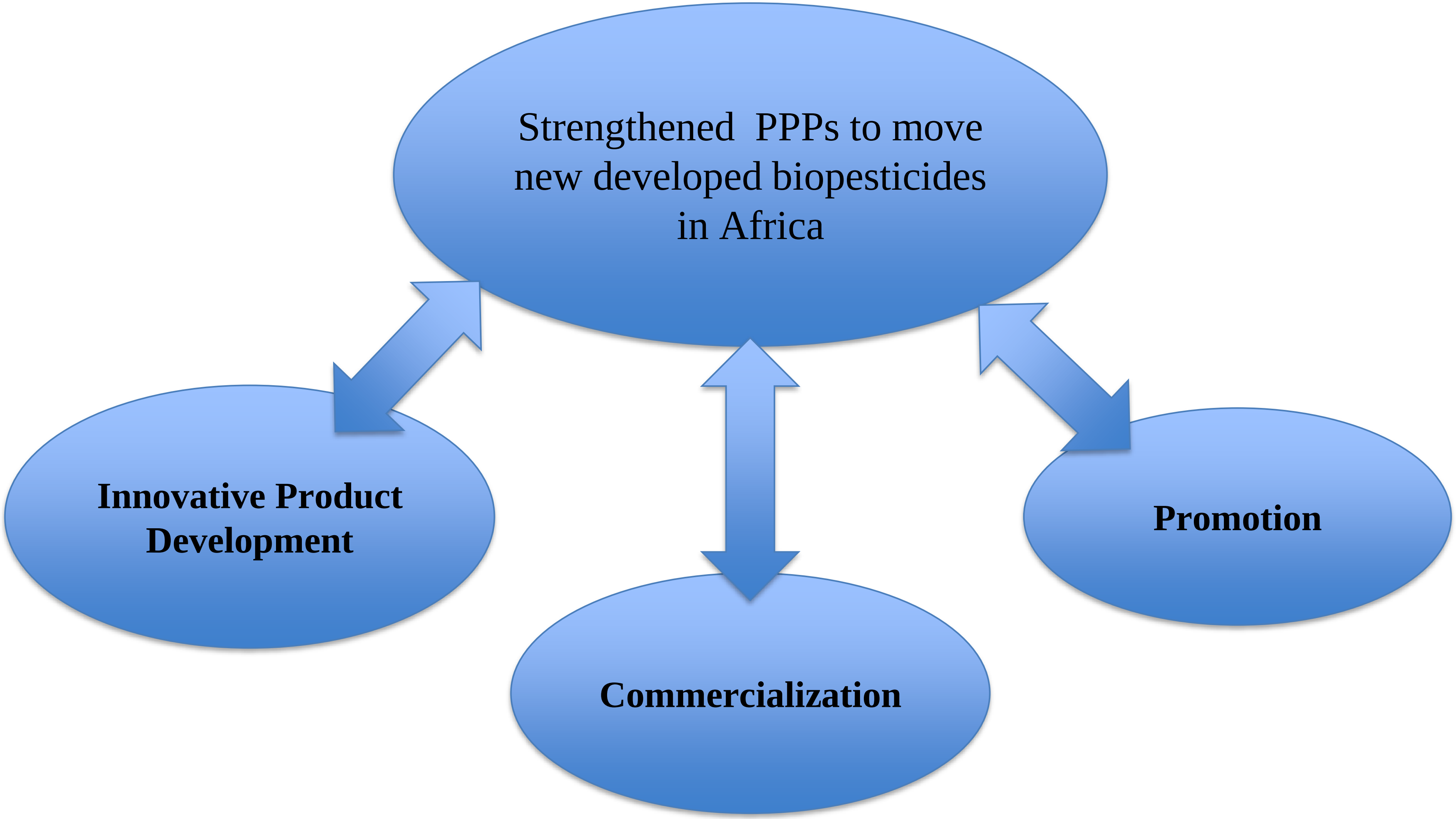
- Biopesticides **$4.4 billion** in 2019; **$10.6 billion** by 2027; will match chemicals by 2050

Predicted growth of Biopesticides sector



Lacey et al. 2015 – *J. Invert. Pathol.* 132, 1–41

PPPs to move new developed biopesticides in Africa



Arthropod Pathology Unit

- Research and innovations on biopesticides
- Bioprospecting for entomopathogens
- Microbes and pests' identification and characterization
- Maintains a long-term repository of entomopathogens
- Capacity-building in insect pathology research
- Commercialization in partnership with private sector

Global food security & why pests control?

Global Forum on Biological Control and Training Workshop on Biological Control

A recent study showed that, insect invasions cost at least $162.7 billion to the global economy & insects reduced the global agricultural production by 10- 16%

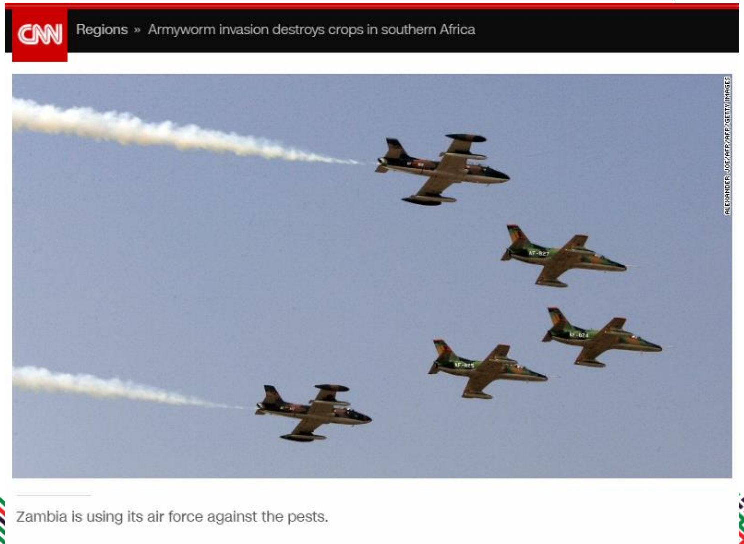
- ❖ While associated health costs exceed $6.9 billion per year
- ❖ Invasive species are costing Africa $3.66 trillion per year – *Nature 592, 571-576 (2021)*

Strategies used to overcome pest losses

- ✓ Increased & abusive use of pesticides/ insecticides (Costly, resistance development, health issues, residues accumulation, non target effects, etc.)
- ✓ Ecological approaches (Resistant host plants, Quarantine, Barriers, Trap crops, Crop diversity, etc.)
- ✓ GMO
- ✓ Cultural practices & Physical control and others…
- ✓ **Biological control** (Predators, Parasitoids, Pathogens (biopesticides) & Biorationals - More sustainable, environmentally friendly, cost effective, etc.)

Invasion of FAW - Over dependence on pesticides

Are there sustainable alternative approaches to pesticides? Yes, Nature regulate itself – How?



Ecosystem & entomopathogens

Ecosystem = community of living organisms in conjunction with the non-living components of their environment & interacting as a system

Ecosystem services = Benefits people obtain from ecosystems. The four categories of ecosystem services – *Supporting, Provisioning, Regulating & Cultural*
https://en.wikipedia.org/wiki/Ecosystem_services

Entomopathogens can also play diverse roles in nature including living as **Epiphytes** or **Endophytes –** microorganisms that colonize internal plant tissues without having any symptomatic effects on the host plant

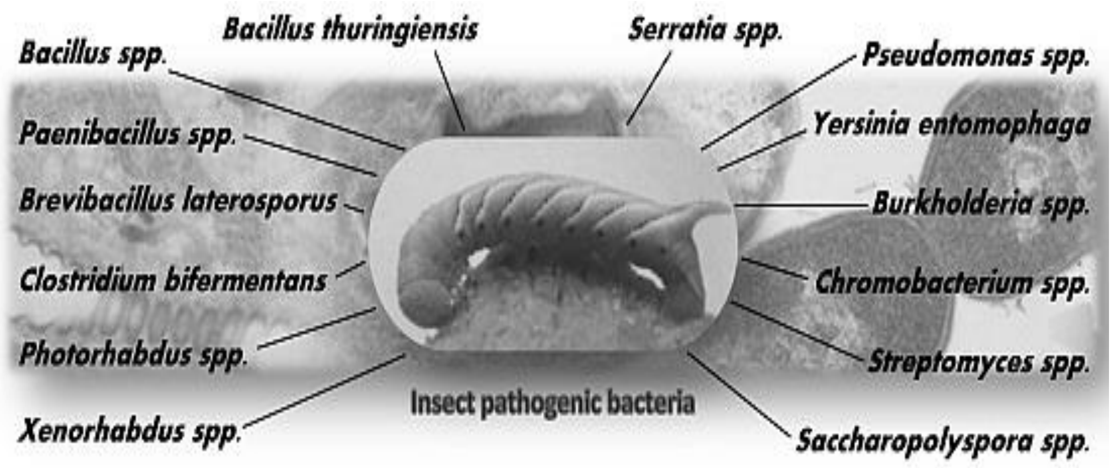
Entomopathogens
= Insect Pathogens

Fungi - *Beauveria bassiana*, *Metarhizium anisopliae*, *Hypocrea lixii*, *Isaria sinclairii*, *Lecanicillium* spp., etc.

Bacteria - *Bacillus thuringiensis*: *Bt. kurstaki*, *Bt. aizawai*, *Bt. israelensis*, *Bt. tenebrionis*, *Bt. Japonensis; Serratia* spp. *& Paenibacillus popilliae*

Nematodes - *Steinernema carpocapsae, S. riobravis, S. scapterisci & Heterorhabditis bacteriophora*

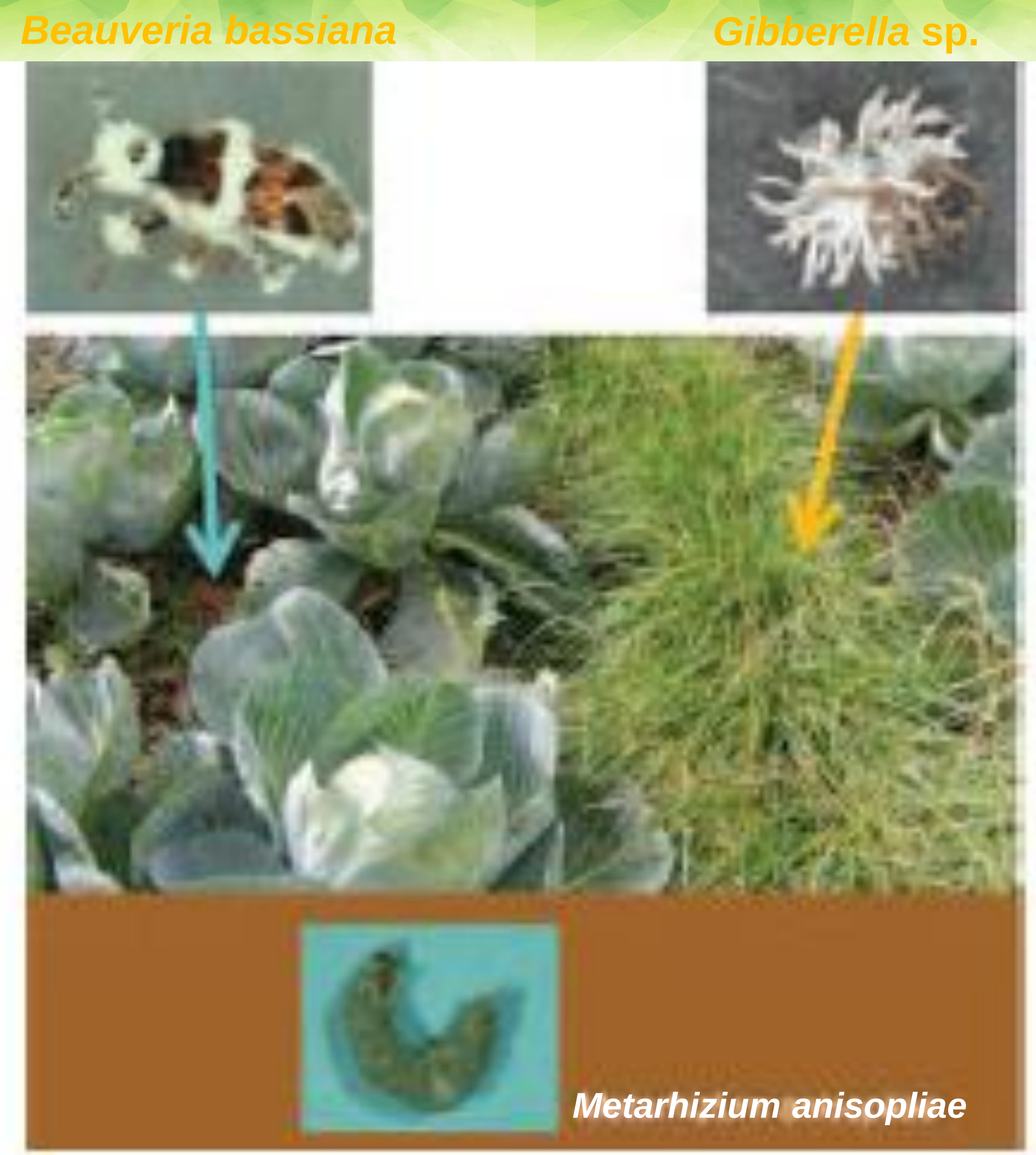
Viruses - Nuclearpolyhedrolysis virus (Japanese Beetle Milky Disease)



Epizootics or epidemics occurred in insect populations & we use these same causal agents as a strategy to control our insect pests **==== Biopesticides development**

Entomopathogenic fungi (EPF) are considered as important BCAs, traditionally applied in inundative approach

However, they can also play diverse roles in nature including living as Endophytes & Biofertilizers



Above & below ground effects of EPF – *"Lifestyle & ability to occupy diverse niches"*

Global Forum on Biological Control and Training Workshop on Biological Control

✓ Below- and aboveground communities of fungal entomopathogens are different

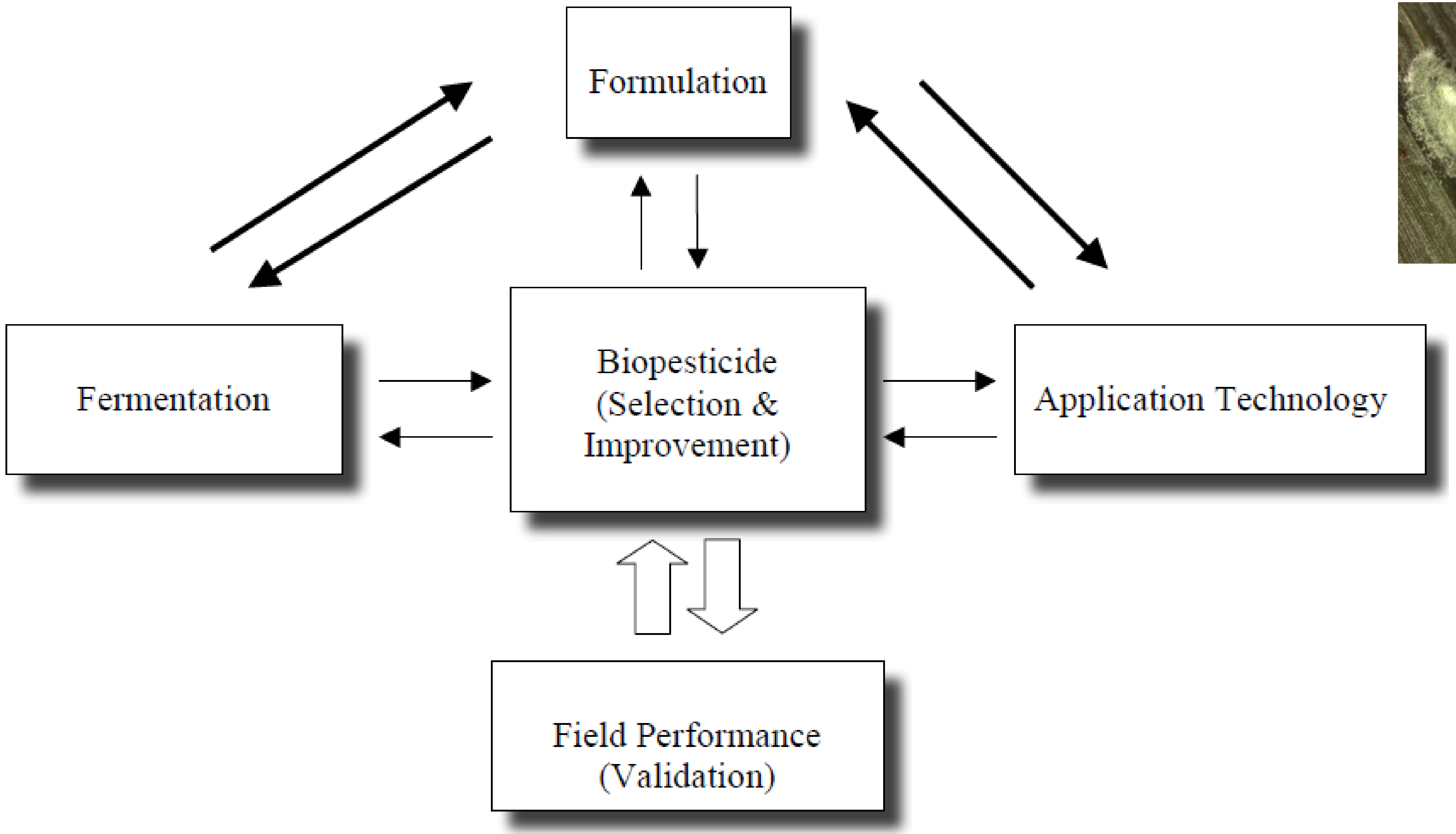
✓ *Metarhizium anisopliae* is most common belowground, but absent aboveground

✓ *Beauveria bassiana* is most commonly infecting arthropods aboveground

✓ *Metarhizium relyi* – known to infect a lot FAW

Food and Agriculture Organization of the United Nations
icipe

Strategic framework for development and evaluation of biopesticides



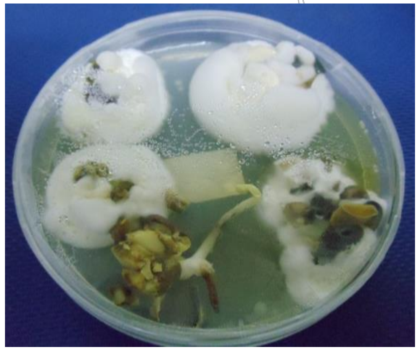
How do we value their service?


- ✓ **Bioprospecting –** Dead, sick, mycosis insects, host plants, soil…
- ✓ **Isolations & Substrates selection –** Detection and isolation / culture and purification
- ✓ **Identification –** Morphological and molecular tools
- ✓ **Bioassays –** reinfection for virulence and efficacy against insect pest
- ✓ **Formulations –** Aqueous & oil formulations (e.g. *Beauveria bassiana* & *Metarizhium anisopliae*)
- ✓ **Virulence & Pathogenicity tests –** Conduct bioassays on target pests to characterize the efficacy of the pathogen
- ✓ **Mass production & Applications –** Inundative & augmentative releases, Autodissemination devices (Pheromone or Lures/ attractants combined with the pathogens)

➢ Proper formulation of a fungal agent, requires a thorough understanding of not only the life cycle of the pathogen, but also the biological aspects of both the fungus & the target host

Fungi isolation technique through surface sterilization & insect bait

- ✓ **Soil** (soil suspension or insect bait: *Galleria mellonella* & *Tenebrio molitor*
- ✓ **Host plants** (Endophytic fungi)
- ✓ **Seeds** (Seed-borne endophytes)
- ✓ **Insects** (Dead, Infected or Mycosed insects)



Beauveria bassiana emerging from *Vicia faba* seeds

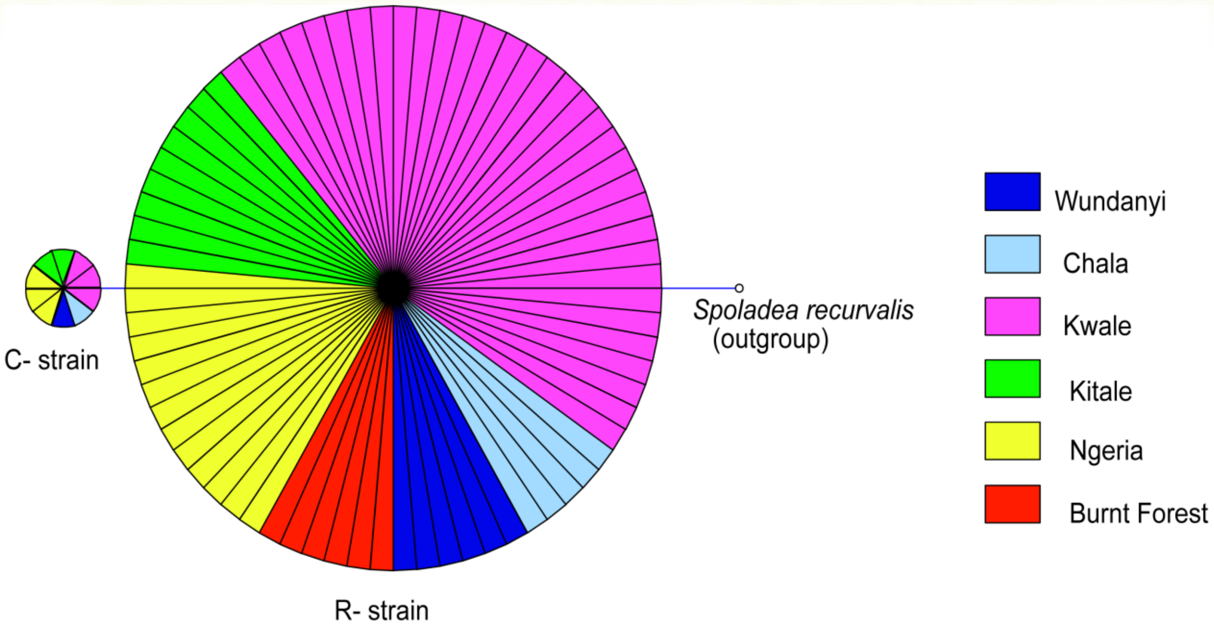
G. mellonella larva infested by *M. anispliae*

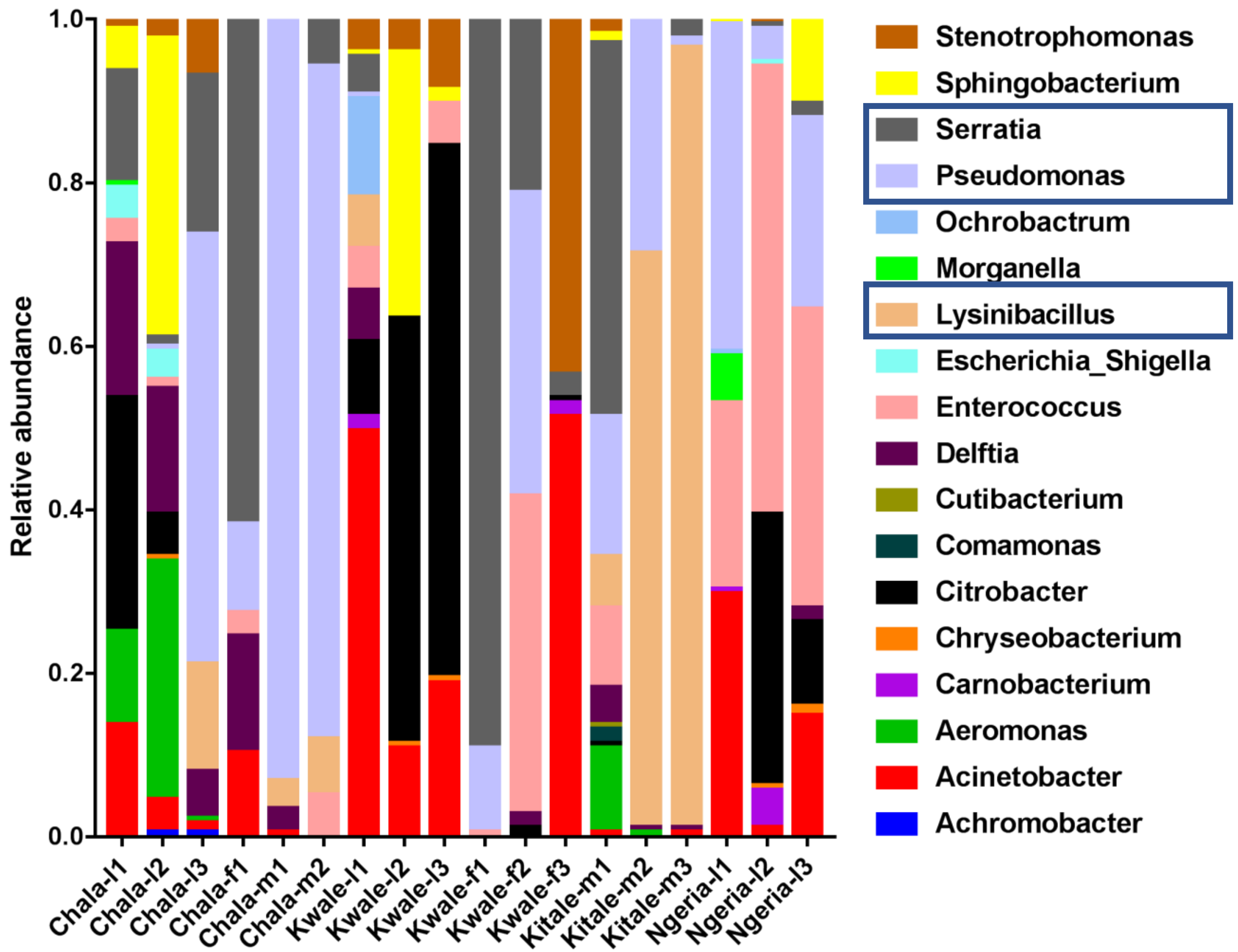
Endophytic fungal colonies emerging from plated plant tissue

G. mellonella larva infested by *B. bassiana*

FAW diversity and gut microbes in Kenya

Global Forum on Biological Control and Training Workshop on Biological Control





PeerJ

Diversity of fall armyworm, *Spodoptera frugiperda* and their gut bacterial community in Kenya

Joseph Gichuhi[1], Subramanian Sevgan[1], Fathiya Khamis[1], Johnnie Van den Berg[2], Hannalene du Plessis[2], Sunday Ekesi[1] and Jeremy K. Herren[1,3]

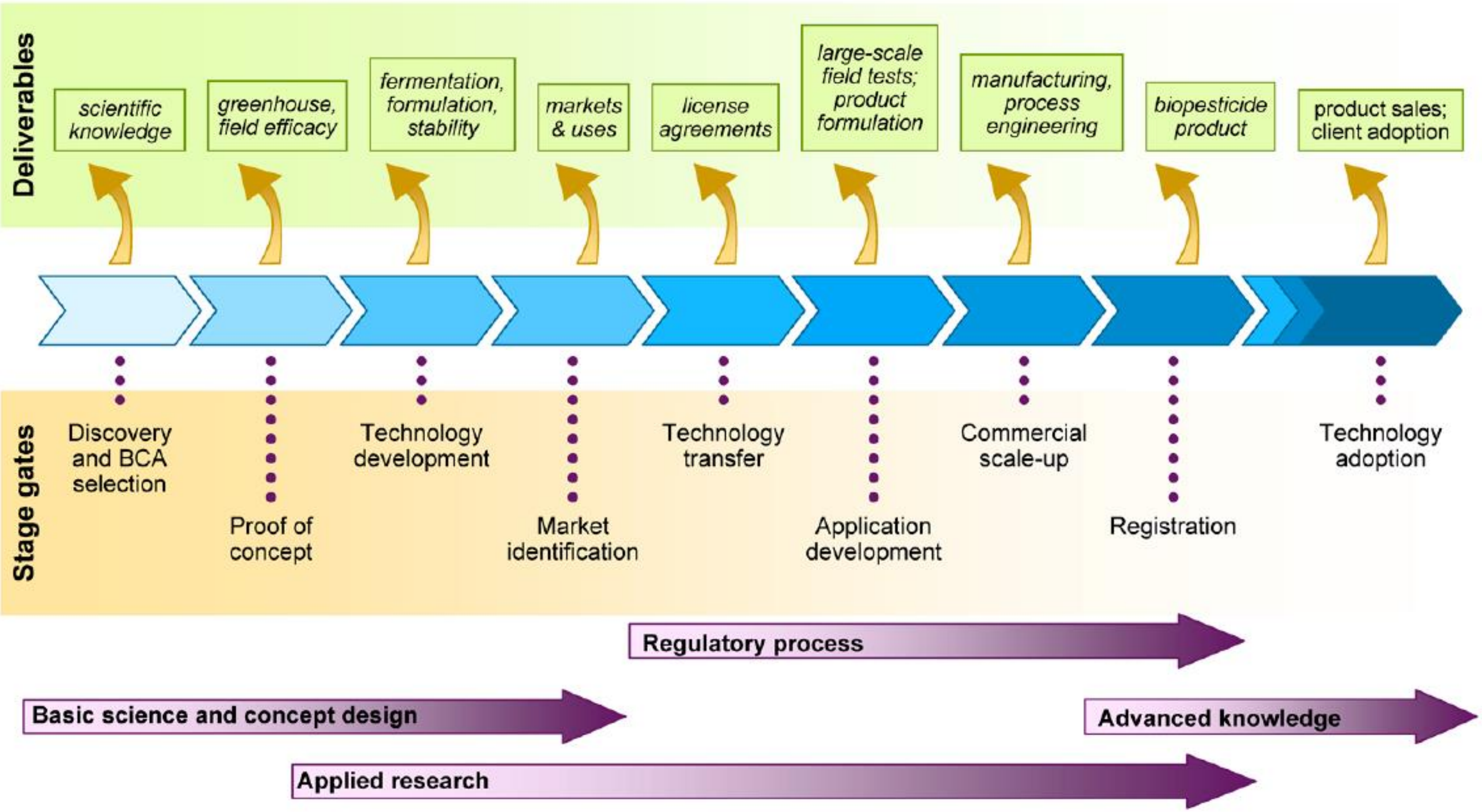
Metarhizium rileyi has been frequently observed in some of the samples.

Epizootics of the ***Metarhizium rileyi*** are also observed regularly in Nairobi

Food and Agriculture Organization of the United Nations

icipe

Biopesticides development pathway – Innovation chain



Delivery of biopesticides – Innovation chain

Bioprospecting and maintenance of a repository of biopesticides

Entomopathogen group	No. of isolates	Genus
Entomopathogenic fungi	311	*Beauveria, Metarhizium, Verticillium, Isaria*, and others
Entomopathogenic bacteria	157	*Bacillus thuringiensis*, *Serratia marcescens* and others
Endophytes	10	*Hypocrea, Trichoderma, Clonostachys,* and *Bionecteria*
Entomopathogenic nematodes	2	*Heterorhabditis* and *Steinernema*
Microsporidian	3	*Nosema, Malamoeba* and *Johenrea locustae*
Baculoviruses	2	*Spodoptera littoralis* NPV and *S. exigua* NPV

frontiers in Sustainable Food Systems

REVIEW
published: 30 September 2020
doi: 10.3389/fsufs.2020.563016

Check for updates

Biopesticide Research and Product Development in Africa for Sustainable Agriculture and Food Security – Experiences From the International Centre of Insect Physiology and Ecology (*icipe*)

Komivi Senyo Akutse, Sevgan Subramanian, Nguya Kalemba Maniania, Thomas Dubois and Sunday Ekesi*

Global Forum on Biological Control and Training Workshop on Biological Control

Plant pests

Whiteflies, *Liriomyza* leafminers, cereal stemborers, diamondback moth, African bollworm, red spider mites, aphids, thrips, fruit flies, pod-borers, pod suckers, storage beetles, false codling moth, fall armyworm and tomato leafminer

Animal pests and disease vectors

Ticks (*Rhipicephalus* sp., *Boophilus sp., Amblyoma* sp.) and tsetse flies (*Glossina* sp.)

Human disease vectors

Mosquitoes, other key vectors include tsetse flies, ticks, sand flies, fleas, black flies and triatomine bug

Parasites and microbes’ screening for safety in insects for food & feed

Biopesticide products

Metarhizium 62	*Metarhizium* 78	*Metarhizium* 7	*Metarhizium* 69
Aphids	Mites	Ticks	Fruit flies Thrips Mealybugs

realIPM biobest SUSTAINABLE CROP MANAGEMENT

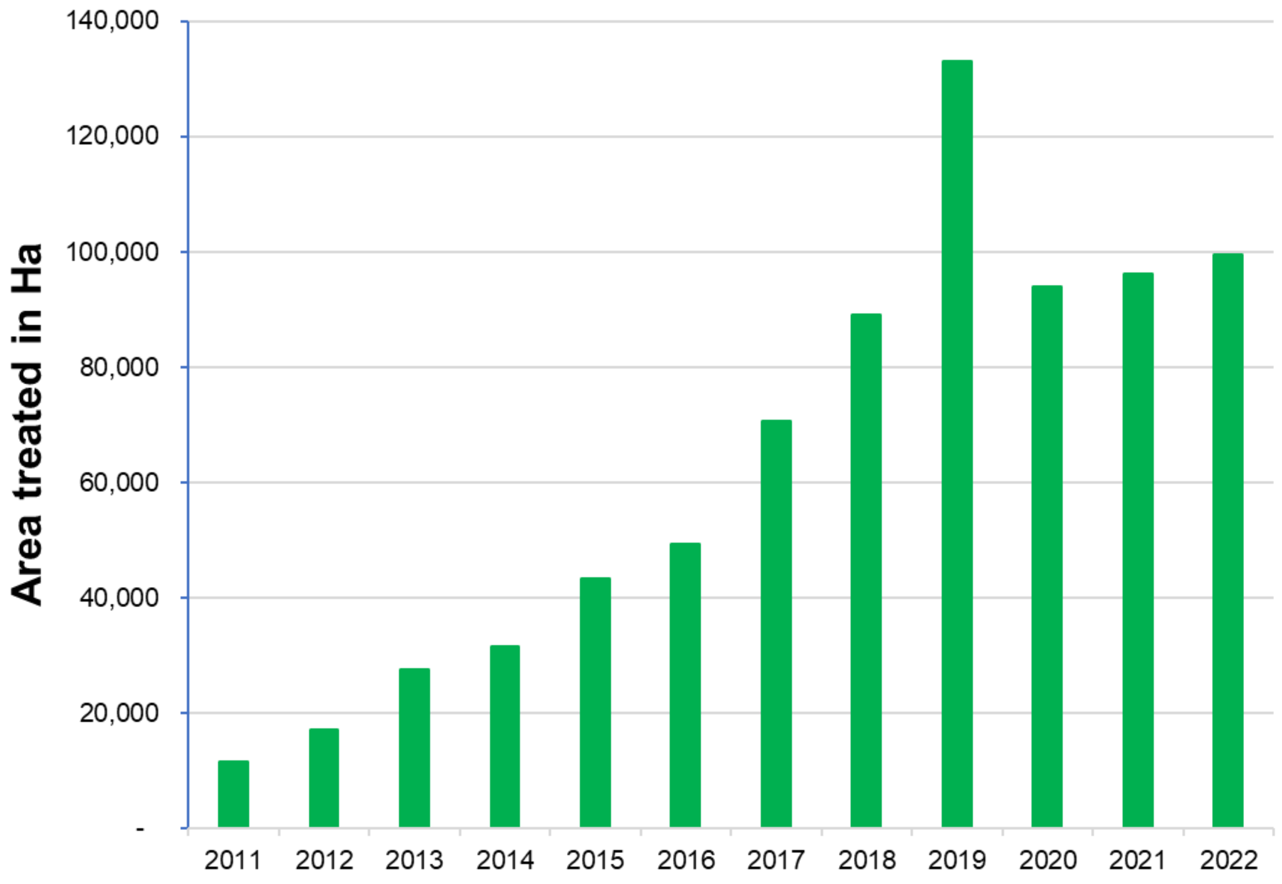
In partnership with *icipe*

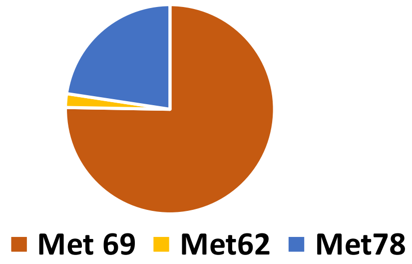
Outreach for commercialized biopesticides

Registration status - Registered in 13 countries

Scaling up of icipe' s commercialized biopesticides

Acreage of biopesticides use





Building private sector partnerships

realIPM

Russell IPM
INTEGRATED PEST MANAGEMENT

HEAL
BIOTECH & AGRICULTURE

éléphant vert

Thank you

Co-organized by

Food and Agriculture Organization of the United Nations

icipe

Supported by

EUROPEAN UNION

USAID
FROM THE AMERICAN PEOPLE

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Global Forum on Biological Control and Training Workshop on Biological Control

Nairobi, Kenya 26-30 June 2023

Prospects and opportunities for Biopesticides (EPF, bacteria, baculoviruses and endophytes) based management of FAW

Komivi S. Akutse - kakutse@icipe.org

Co-organized by

Food and Agriculture Organization of the United Nations

icipe

Supported by

EUROPEAN UNION

USAID FROM THE AMERICAN PEOPLE

german cooperation DEUTSCHE ZUSAMMENARBEIT

Implemented by giz

Sustainable Fall armyworm IPM strategy for Africa

EUROPEAN UNION

icipe

FAW-IPM Africa-specific, science-led, sustainable and integrated management of the fall armyworm

KALRO Kenya Agricultural & Livestock Research Organization

LZARDI Lake Zone Agricultural Research & Development Institute

RWANDA RAB AGRICULTURE BOARD

Ethiopian Institute of Agricultural Reasearch

NARO

Foreign, Commonwealth & Development Office

FAW Biopesticides development & upscaling

- Enhanced productivity and food security ensured
- Safer environments and products
- Better livelihoods

Building on icipe' s biopesticide experience

Identification of effective biopesticides against the invasive FAW

Development of a biopesticide products for all stages for FAW

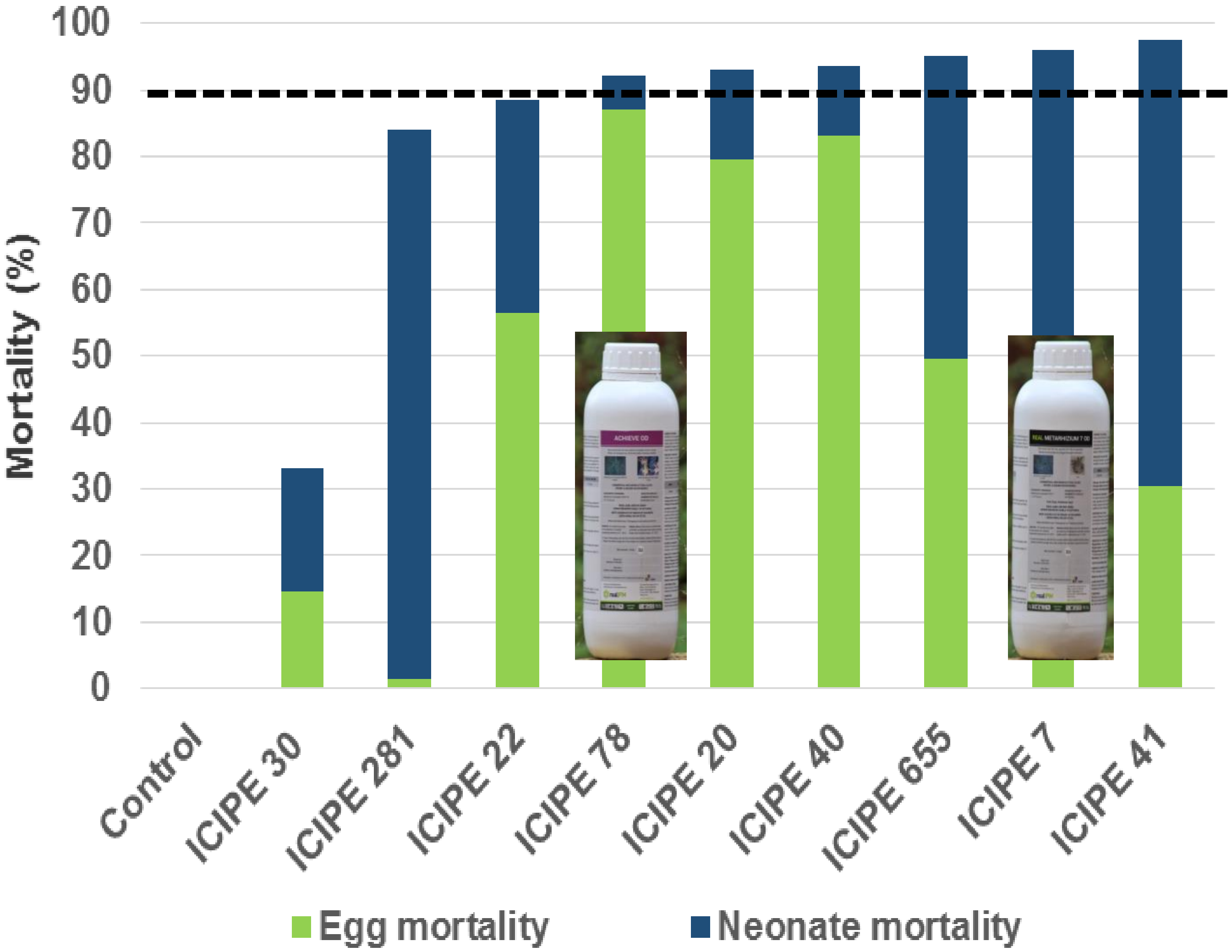
Insect viral diseases – eg.
Baculoviruses

Insect bacterial diseases – eg.
Bacillus thuringiensis

Insect fungal diseases – eg.
Metarhizium anisopliae; Beauveria bassiana

Efficacy of EPFs against FAW egg and newly emerged larvae

Global Forum on Biological Control and Training Workshop on Biological Control



ORIGINAL CONTRIBUTION

WILEY JOURNAL OF APPLIED ENTOMOLOGY

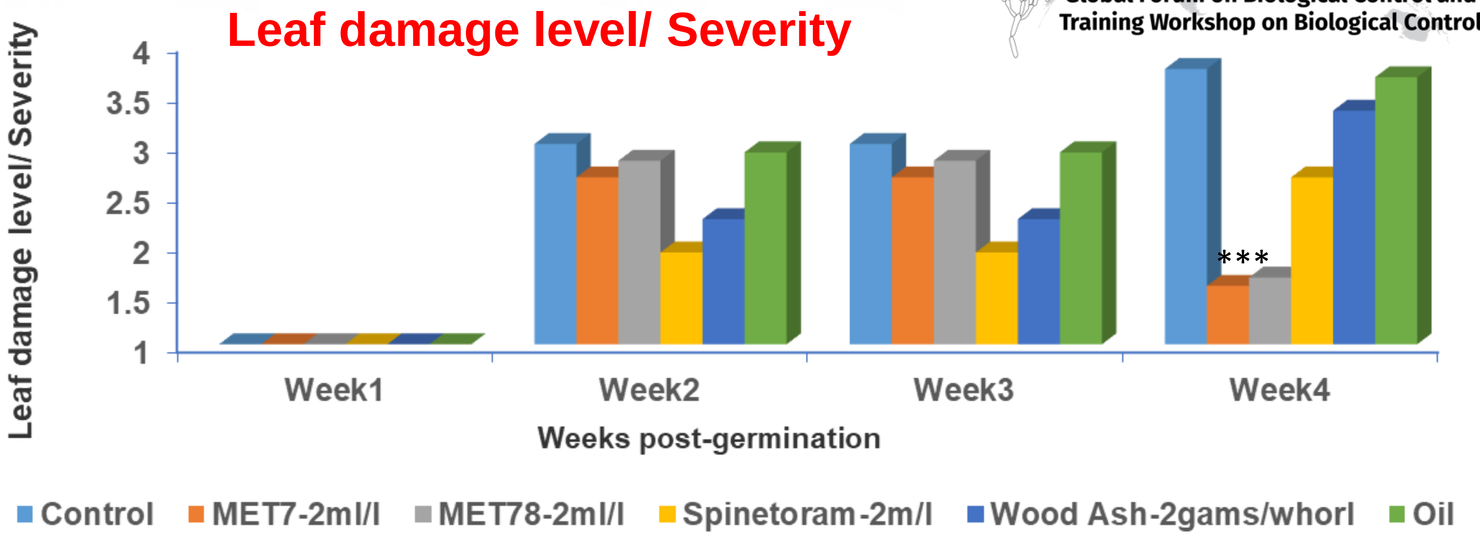
Ovicidal effects of entomopathogenic fungal isolates on the invasive Fall armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

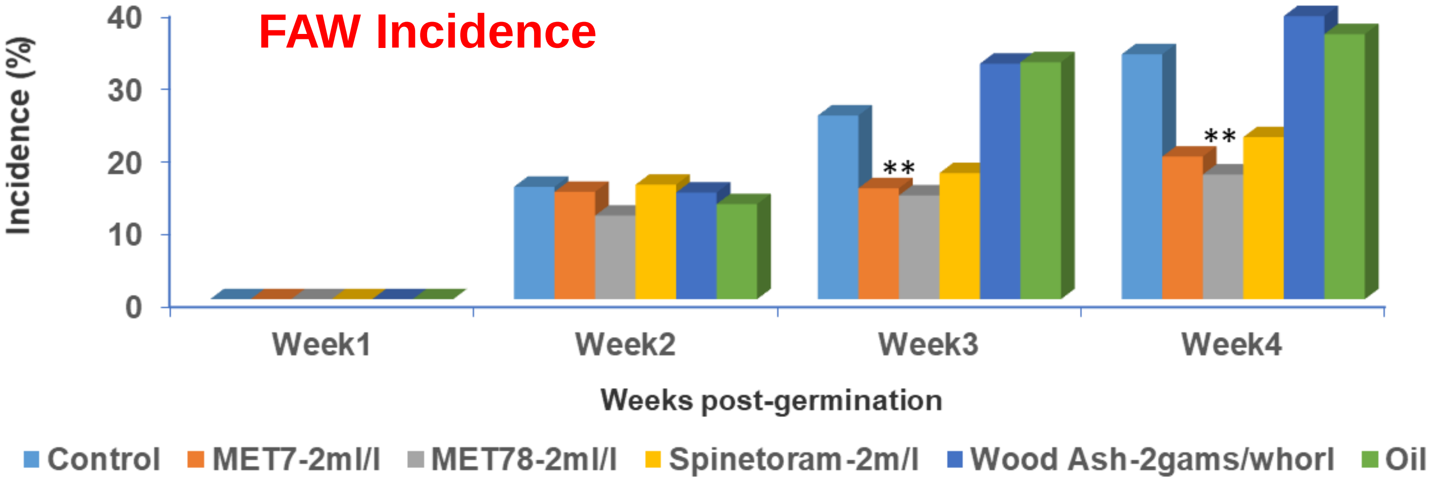
Komivi Senyo Akutse | Jane Wanjiru Kimemia | Sunday Ekesi | Fathiya Mbarak Khamis | Odhiambo Levi Ombura | Sevgan Subramanian

Food and Agriculture Organization of the United Nations

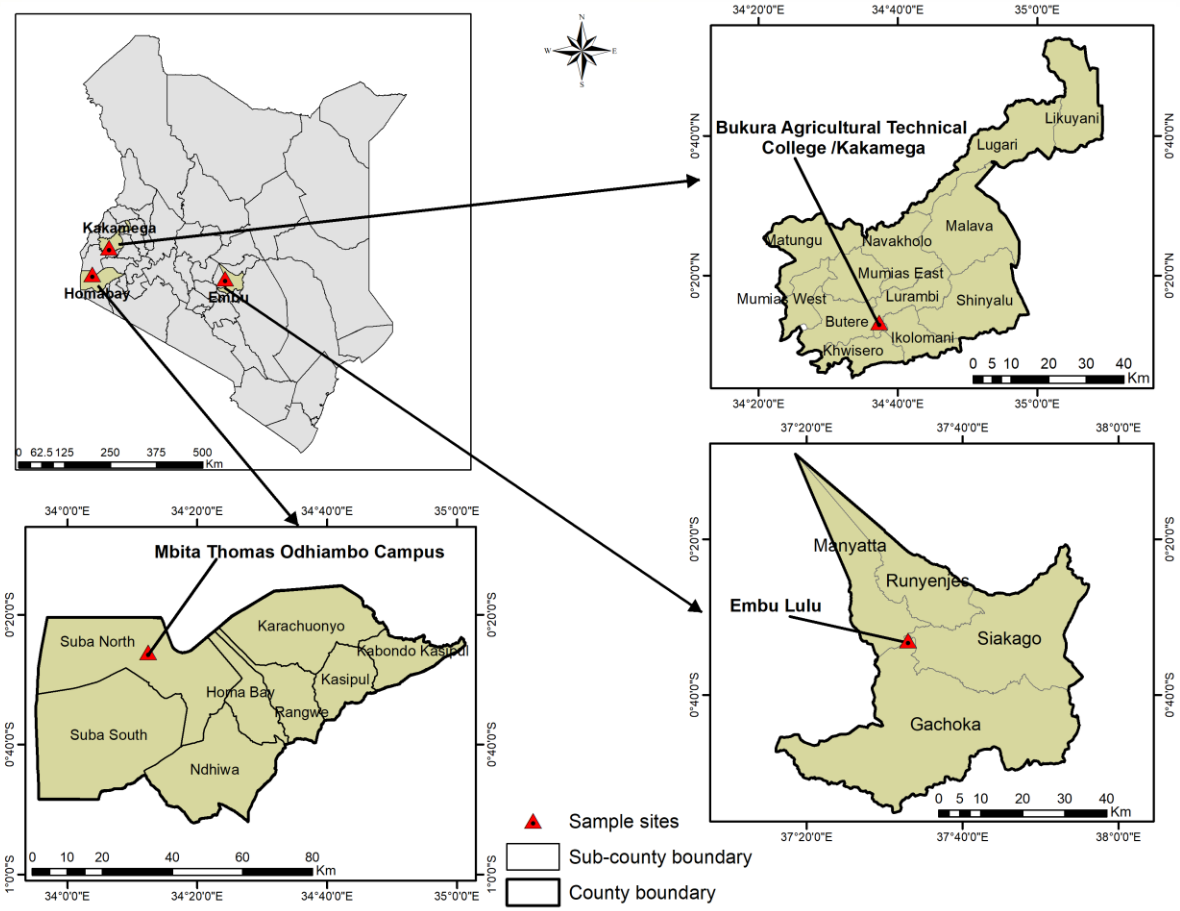
icipe

Field efficacy trial with ICIPE 7 & ICIPE 78 – Embu, Kenya





Field Efficacy Trial in Kenya – incidence of damage caused by FAW



Met 7 & **Met 78** have reduced the damage incidence equally to chemical by >60%

For severity of damage and yield

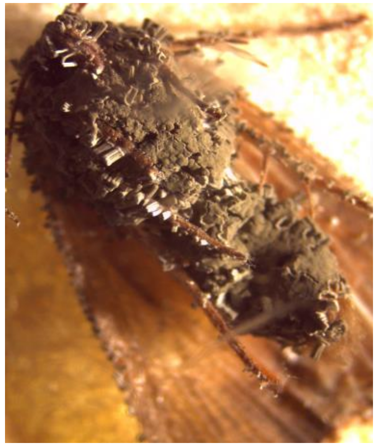
- ✓ **No significant difference were observed for Cob width and length**
- ✓ **More yield were obtained in T2, T3 and T4 in Embu**

****Registered – 2021 in Kenya; 2022 in Uganda and Tanzania**

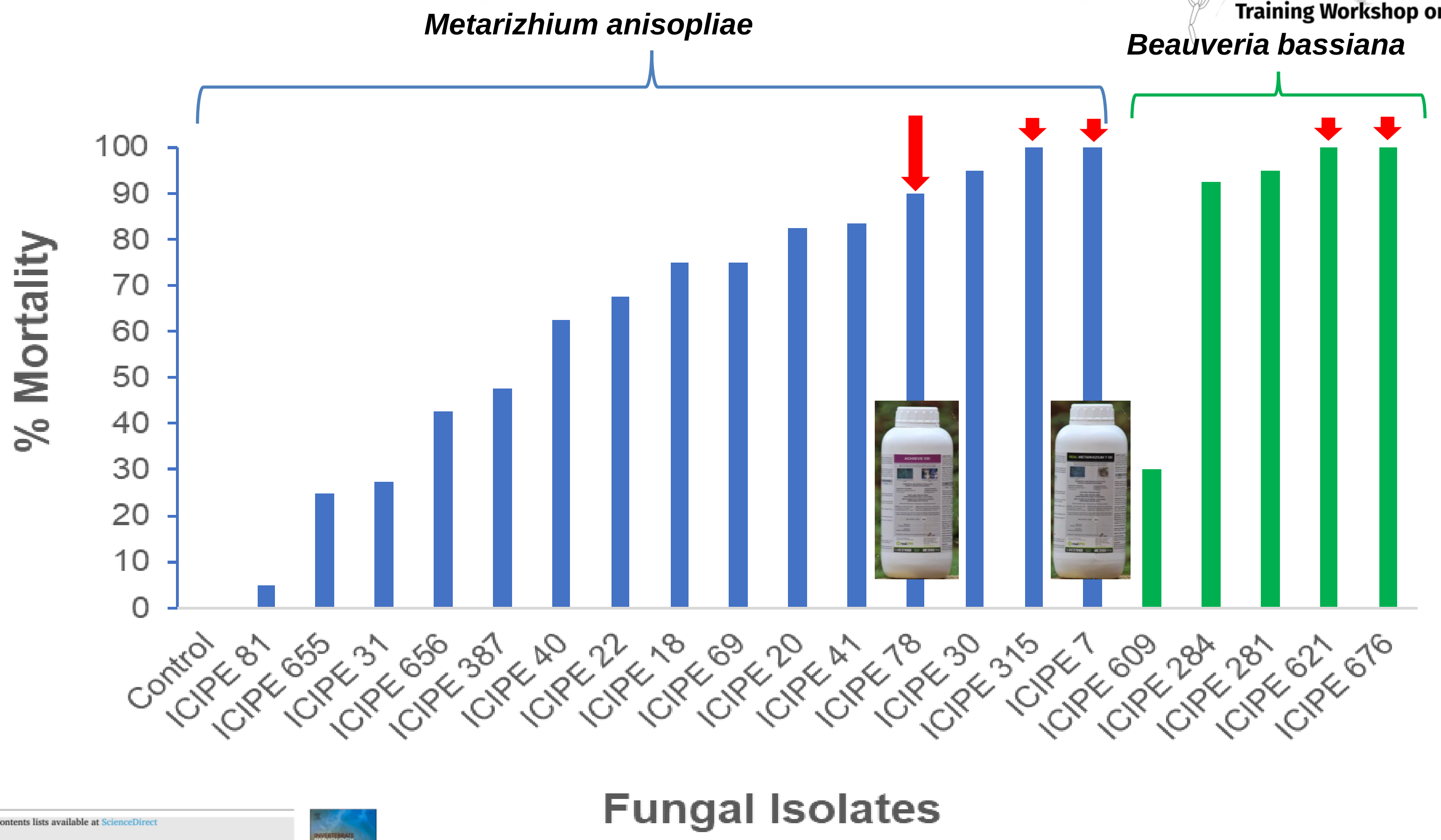
T1- Control (Water only as application) ; **T2-** Met 7 (Oil formulation); **T3-** Met 78 (Oil formulation); **T4-** Chemical (Radiant); **T5-** Wood ash; **T6-** Mixit (Oil only as application)

Efficacy of EPF on FAW adults

Healthy



Fungus-infected




Contents lists available at ScienceDirect

Journal of Invertebrate Pathology

journal homepage: www.elsevier.com/locate/jip

ELSEVIER

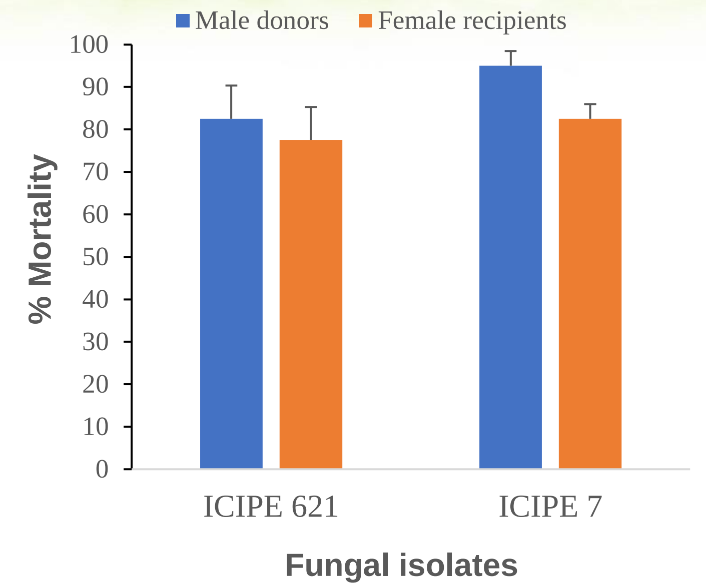
Combining insect pathogenic fungi and a pheromone trap for sustainable management of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

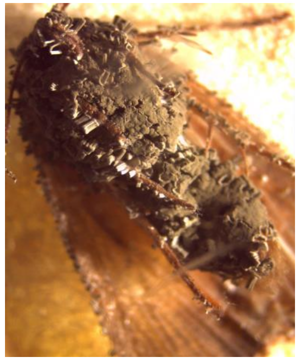
Komivi S. Akutse [a,*], Fathiya M. Khamis [a], Felicitas C. Ambele [a,b], Jane W. Kimemia [a], Sunday Ekesi [a], Sevgan Subramanian [a]

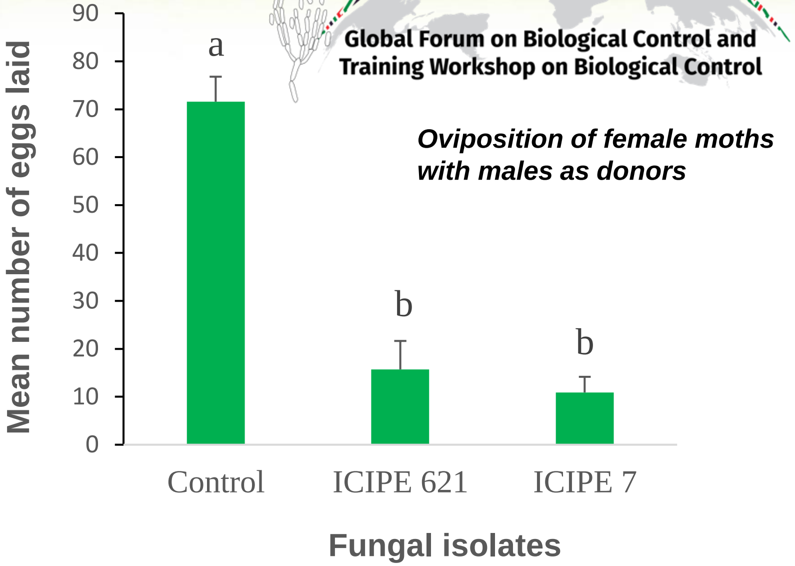
- ***M. anisopliae*** – ICIPE 315 & ICIPE 7 and ***B. bassiana*** – ICIPE 621 & ICIPE 676 caused 100% mortality

Effect of horizontal transmission of EPF inoculum as per FAW sex

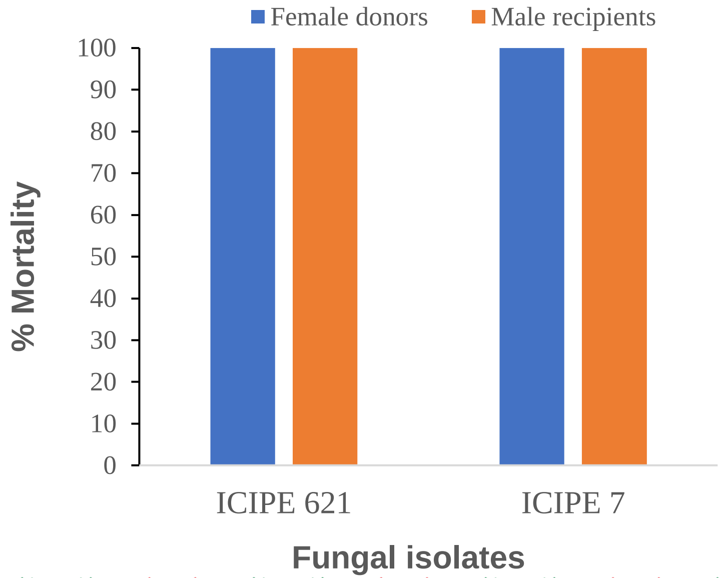
Global Forum on Biological Control and Training Workshop on Biological Control







None of the eggs hatched in the fungal treatments Vs. 100% hatchability in the control



Journal of Invertebrate Pathology 177 (2020) 107477

Contents lists available at ScienceDirect

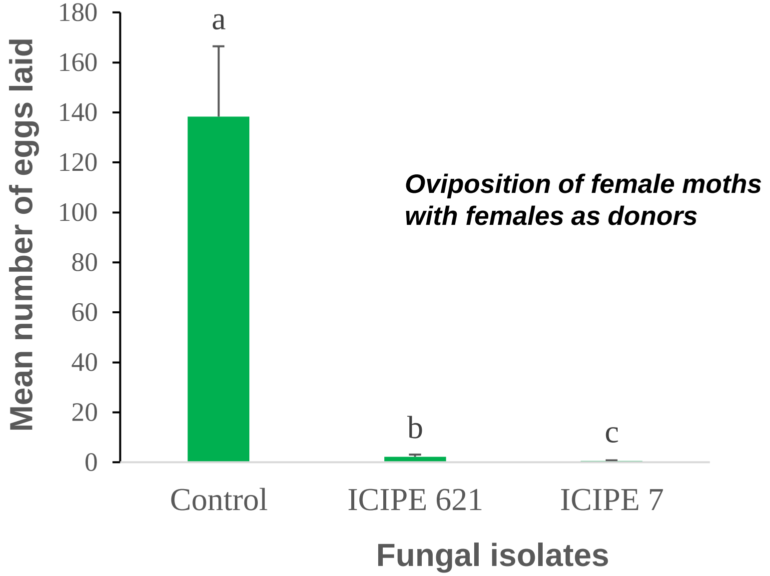
Journal of Invertebrate Pathology

journal homepage: www.elsevier.com/locate/jip

ELSEVIER

Combining insect pathogenic fungi and a pheromone trap for sustainable management of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

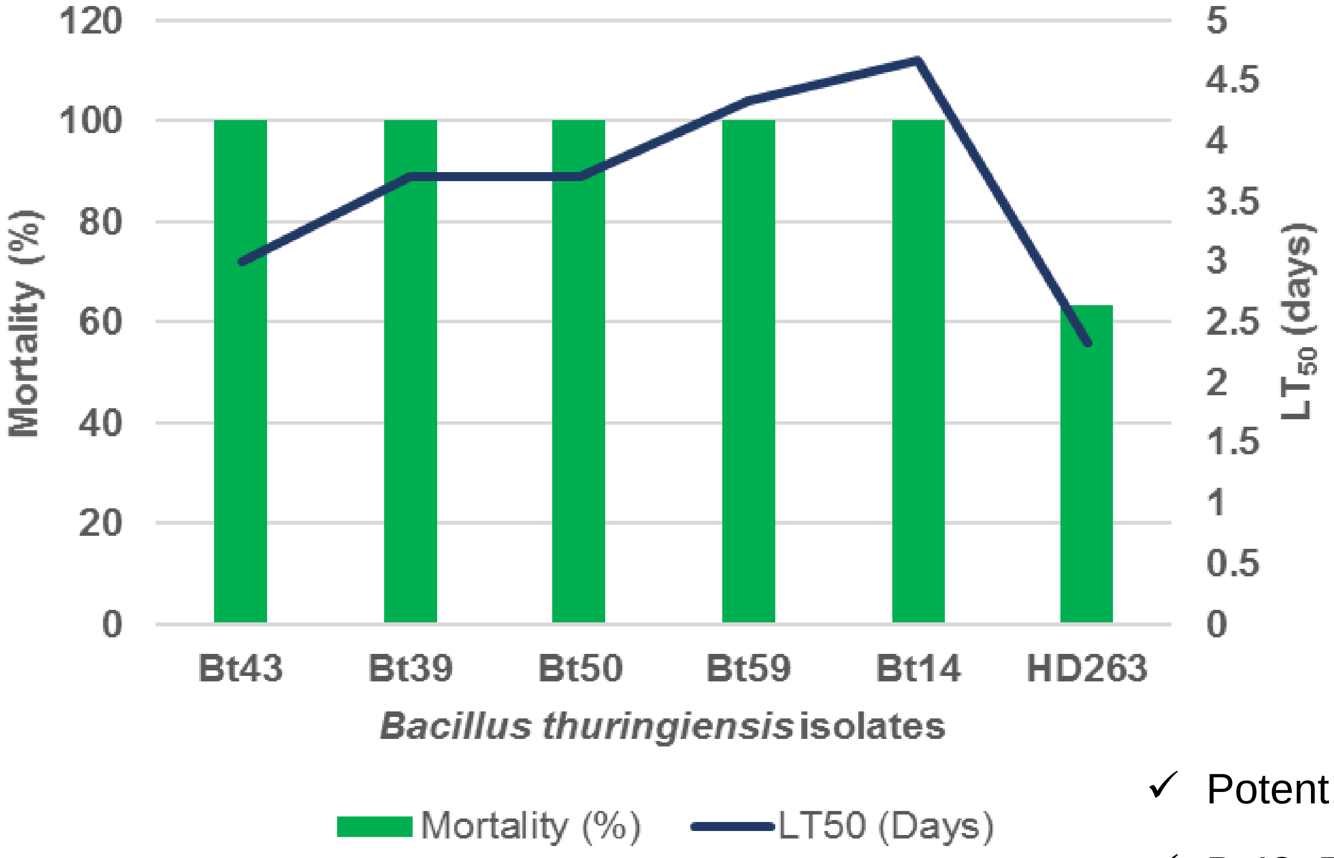
Komivi S. Akutse[a,*], Fathiya M. Khamis[a], Felicitas C. Ambele[a,b], Jane W. Kimemia[a], Sunday Ekesi[a], Sevgan Subramanian[a]



Food and Agriculture Organization of the United Nations

icipe

Development of biopesticides – Bt against FAW larvae



- ✓ Potent Bt isolates identified.
- ✓ Bt43, Bt39 and Bt50 holds promise with higher mortality and faster kill of FAW.
- ✓ Field efficacy studies are planned with the private sector partners.

Baculoviruses for FAW management in Africa

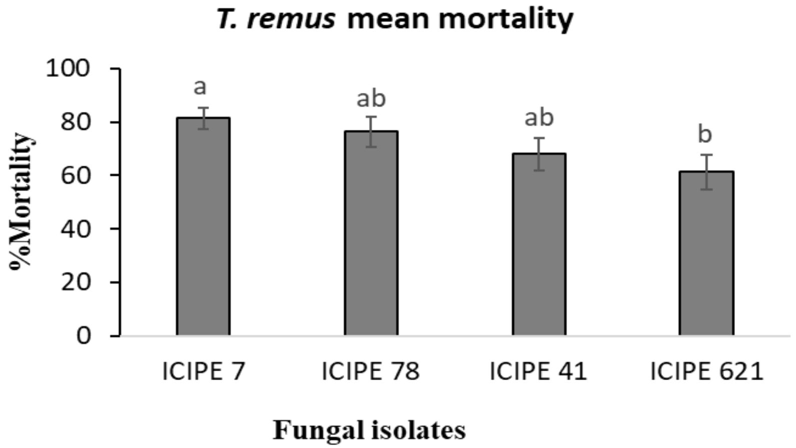
- Novel baculovirus “Fawligen” tested in Kenya
- Maize yield advantage of 1.5 t/ha over untreated control
- Fawligen officially registered in Kenya (Feb 2021)
- Community small-holder production being tested
- 95% of farmers willing to pay for biopesticide if available at an agro-dealer near to them, at a price comparable to a synthetic insecticide

Source: **Ivan Rwomushana**. Senior Scientist, Invasive Species Management. **CABI**

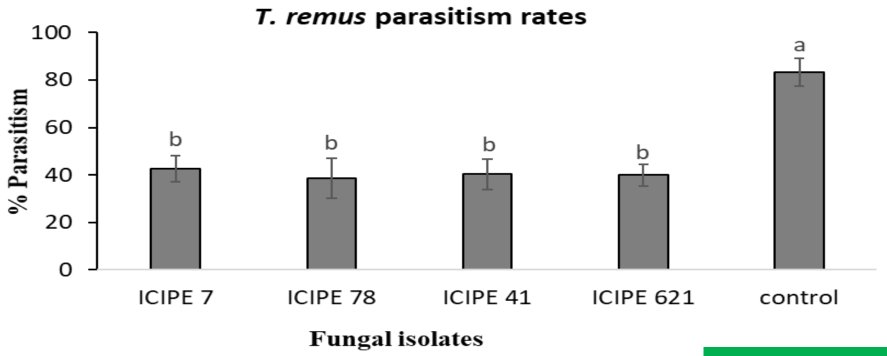
R4D support for enhancing product effectiveness, non-target effects & Capacity building

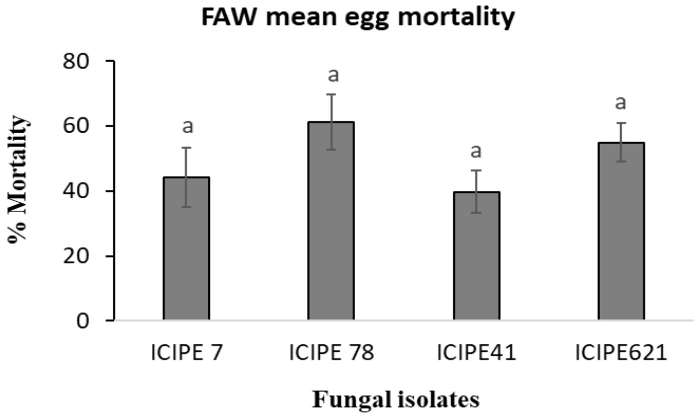
Non target effects on major FAW parasitoids – Direct effects

Global Forum on Biological Control and Training Workshop on Biological Control



ICIPE 7 caused the highest mortality rate at 81.40%





ICIPE 78 caused the highest (61.25%) FAW eggs mortality

Cotesia icipe

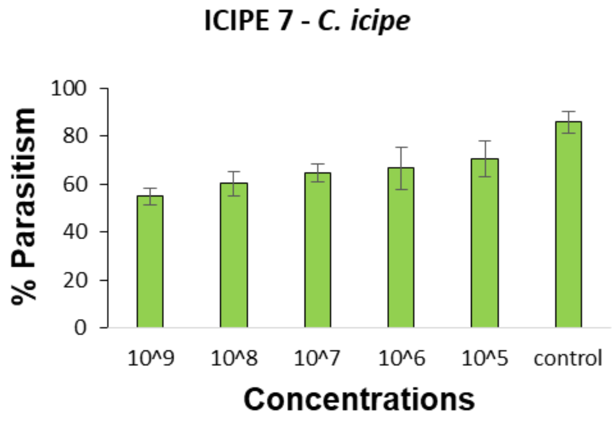
Fungal isolates	Mean mortality%	Larval mortality	Parasitism rates	Sex ratios (F:M)	*Cotesia icipe* LT_{50}
***M. anisopliae* ICIPE 7**	73.95±7.49a	55.25±6.74a	35.75±4.80b	2:1	2.3±0.03a
***M. anisopliae* ICIPE 78**	33.63±6.63b	28.25±4.41b	62.00±5.02a	2:1	5.2±0.06c
***M. anisopliae* ICIPE 41**	66.33±7.29a	53.75±3.91a	36.75±3.82b	2:1	2.8±0.04b
***B. bassiana* ICIPE 621**	36.59±6.65b	31.00±5.29b	58.00±5.24a	2:1	5.0±0.06d

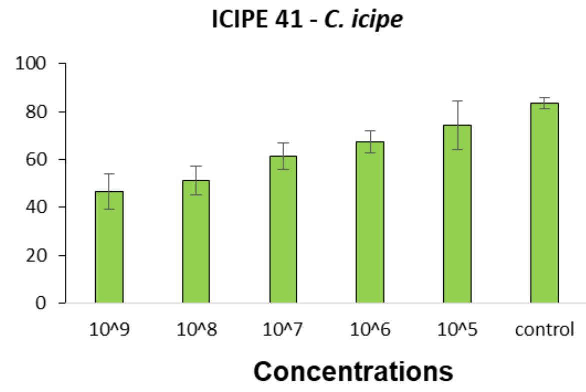
High parasitism rates were obtained in ICIPE 78 and ICIPE 621 & ICIPE 7 and ICIPE 41 had lowest LT_{50}

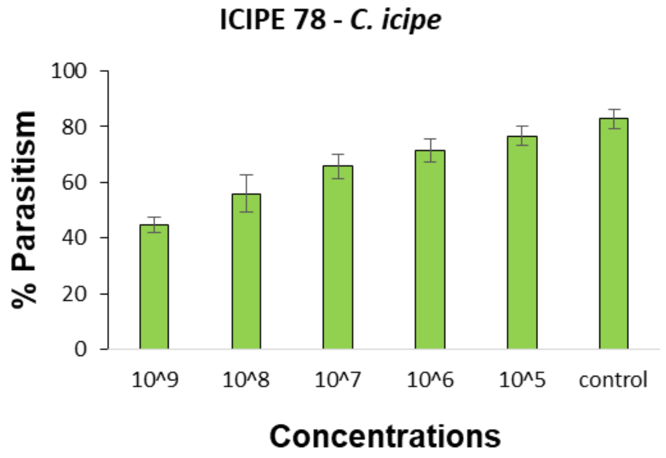
Food and Agriculture Organization of the United Nations

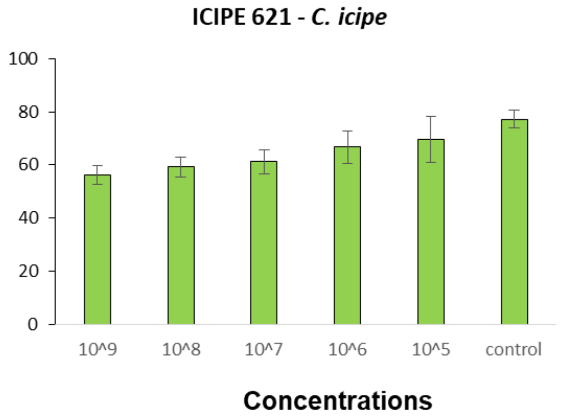
icipe

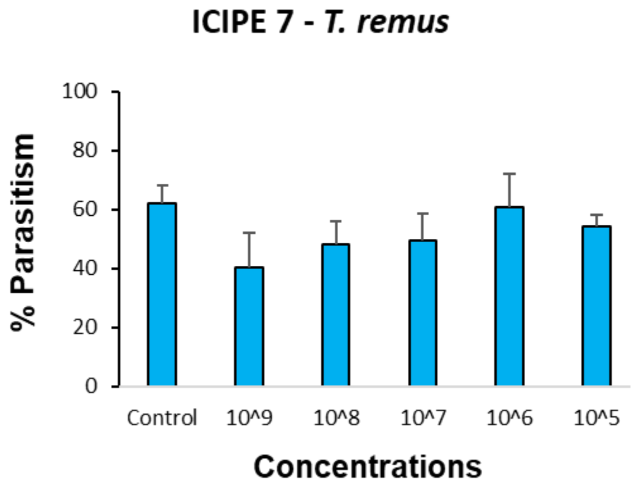
Non target effects on major FAW parasitoids – Indirect effects

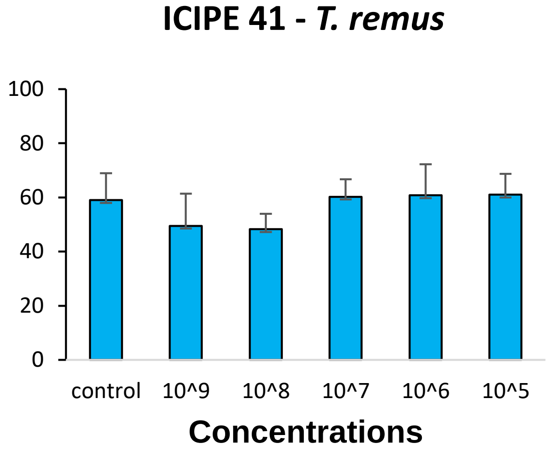


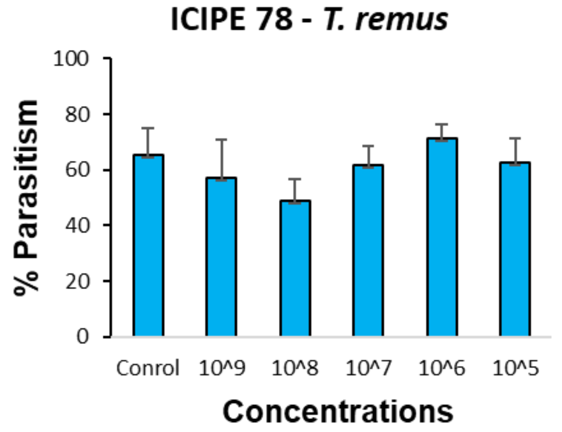


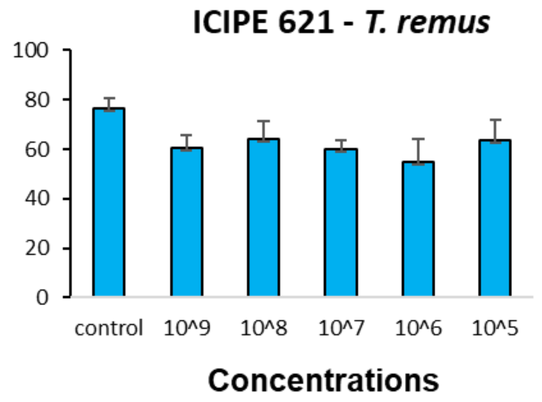












Cotesia icipe

Indirect application **of the biopesticides at lower concentrations could be applied together with the parasitoids without affecting their performance**

Telenomus remus

Efficacy of various oil formulations of M. anisopliae ICIPE 41 on FAW

Fungal isolate	Fungal formulation	Larvae cumulated mortality (%)	Lethal time 50% (LT_{50})
Metarhizium anisopliae ICIPE 41	Canola oil formulation	76.07 ± 6.43b	2.06 ± 0.15b
	Corn oil formulation	72.5 ± 5.58b	2.26 ± 0.36b
	Olive oil formulation	70.36 ± 6.66b	2.52 ± 0.43b
	Aqueous formulation	15.15 ± 2.86a	8.11 ± 1.53a

Effects of oil formulations of M. anisopliae ICIPE 41 on FAW parasitoids

Treatments	*Cotesia icipe*	*Telenomous remus*	*Trichogramma* spp.
Canola oil Formulation	82.5 ± 4.33a	21.3 ± 3.14b	26.3 ± 3.75b
Olive oil Formulation	52.5 ± 9.68b	15.0 ± 2.04b	23.8 ± 2.39b
Corn oil Formulation	12.5 ± 3.23c	2.5 ± 1.44a	8.8 ± 1.25a
Aqueous Formulation	52.5 ± 9.68b	11.3 ± 1.25b	23.8 ± 2.39b
Control	2.5 ± 1.44d	2.5 ± 1.44a	5.0 ± 2.04a

Mortality rates of the parasitoid species induced by indirect application of ICIPE 41 formulations

Parasitism rates obtained after indirect application of ICIPE 41 formulations

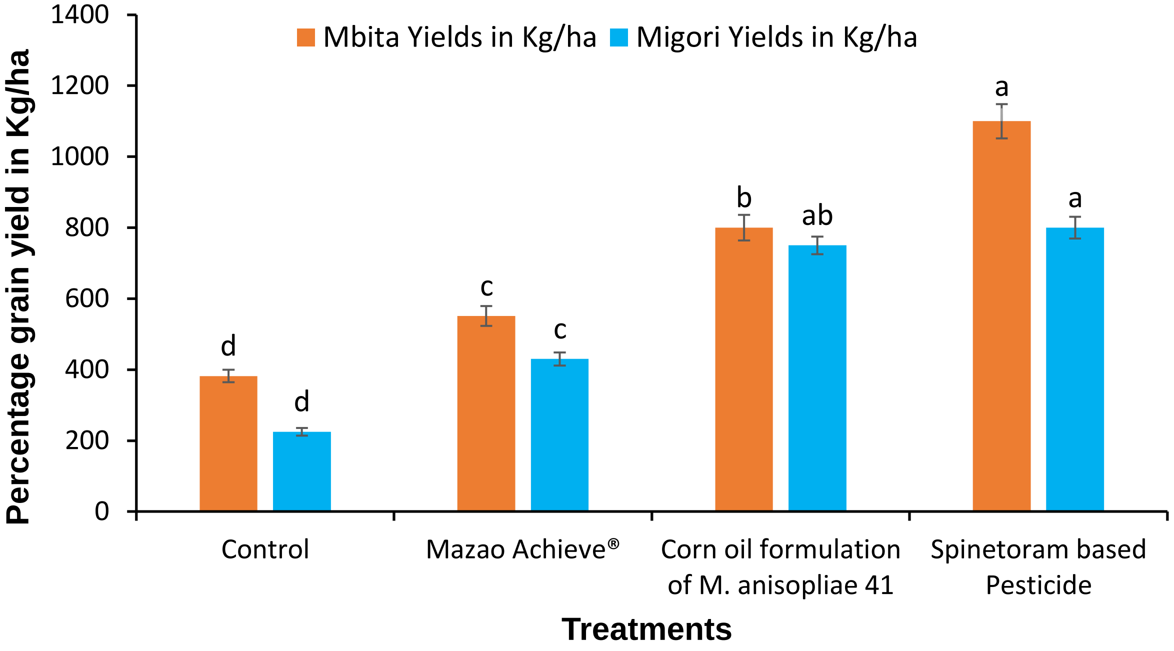
Parasitoids / Treatments	*Cotesia icipe*	*Telenomous remus*	*Trichogramma* spp.
Canola oil Formulation	31.5 ± 2.85a	30.2 ± 2.65a	33.5 ± 2.85a
Olive oil Formulation	44.1 ± 7.23ab	38.8 ± 8.43ab	40.0 ± 5.21ab
Corn oil Formulation	79.3 ± 2.94c	87.3 ± 2.50c	82.3 ± 2.34c
Aqueous Formulation	54.3 ± 4.12b	49.1 ± 4.42b	47.1 ± 7.23b
Control	84.3 ± 3.74c	87.3 ± 2.50c	85.2 ±3.98c

Efficacy of ICIPE 41 on FAW and maize grain yield at Migori and Mbita

Global Forum on Biological Control and Training Workshop on Biological Control

Treatments	% FAW larvae mortality	% Mycosis	Lethal time 50% ± SE
Migori			
Spinetoram-based pesticide/ Radiant	96.1 ± 2.5 a	0.0 ± 0.0 c	3.8 (3.80–3.90) b
Mazao Achieve®	73.0 ± 1.3 c	30.0 ± 0.7 b	5.1 (5.12–5.26) a
Corn oil formulation of *M. anisopliae* ICIPE 41	81.3 ± 2.6 b	70.0 ± 0.5 a	5.2 (5.22–5.32) a
Control	-	0.0 ± 0.0 c	-
Mbita			
Spinetoram-based pesticide/ Radiant	98.7 ± 1.3 a	0.0 ± 0.0 c	3.8 (3.80–3.88) b
Mazao Achive®	74.3 ± 2.5 c	25.0 ± 0.4 b	4.7 (4.70–4.82) a
Corn oil formulation of *M. anisopliae* ICIPE 41	83.6 ± 1.5 b	66.3 ± 0.7 a	4.6 (4.56–4.68) a
Control	-	0.0 ± 0.0 c	-

Cumulated larval mortality induced by different treatments and their lethal time 50% (LT_{50}) after applications



agronomy

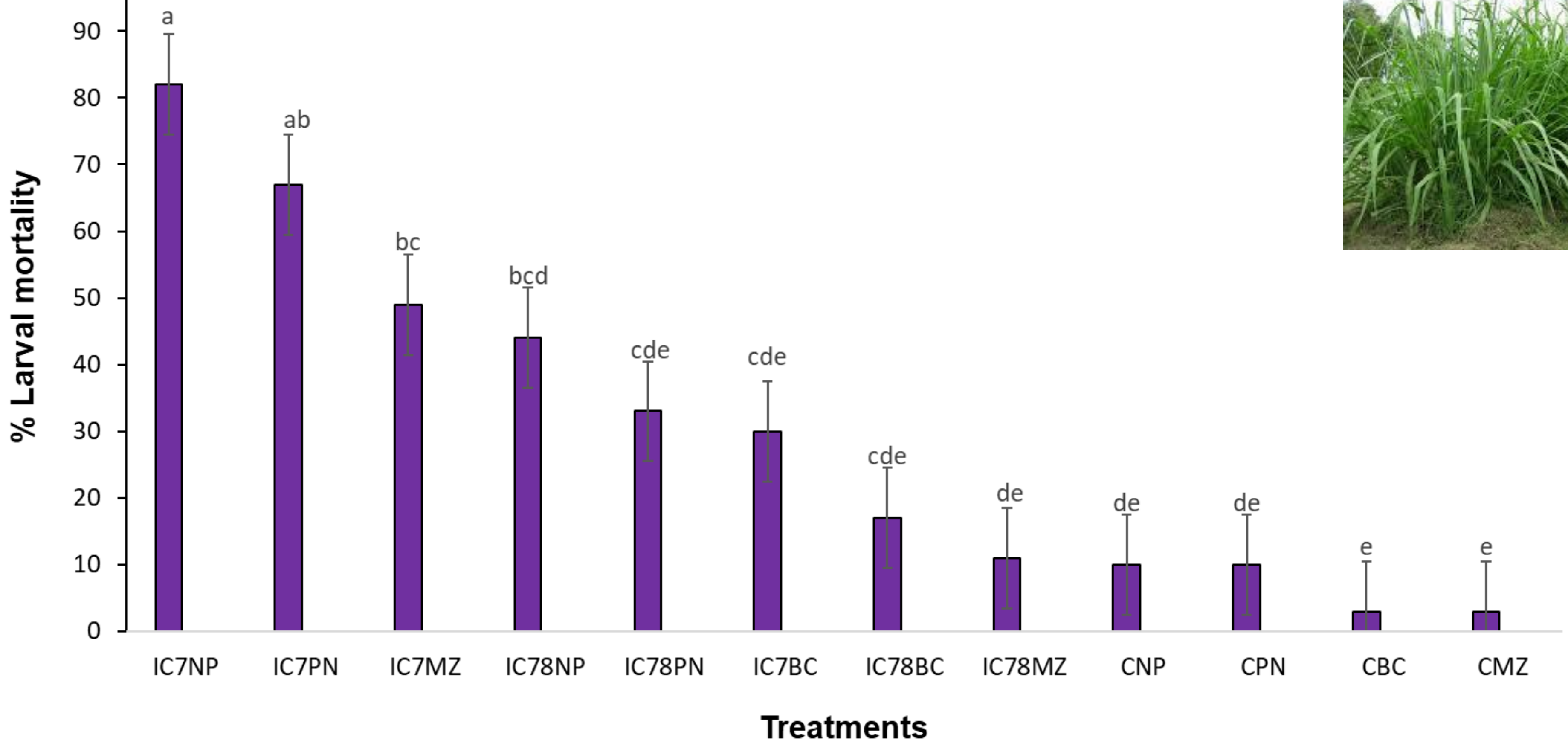
MDPI

Article

Performance of *Metarhizium anisopliae* Isolate ICIPE 41 in the Laboratory and Field in Comparison to Another Fungal Biopesticide and a Chemical Product to Sustainably Control the Invasive Fall Armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

Joseph Munywoki [1,2], Leonidah Kerubo Omosa [3], Sevgan Subramanian [1], David Kupesa Mfuti [1], Ezekiel Mugendi Njeru [2], Vaderament-A. Nchiozem-Ngnitedem [3] and Komivi Senyo Akutse [1,*]

Host plants effects on efficacy of entomopathogenic fungal-based biopesticides in the management of Fall armyworm



On forage plants, *M. anisopliae* ICIPE 7 caused highest mortality of 82% to larvae fed on Napier grass, followed by 67% larvae fed on Panicum as compared to Maize and Brachiaria

Determining effectiveness of nature-based solutions to manage FAW

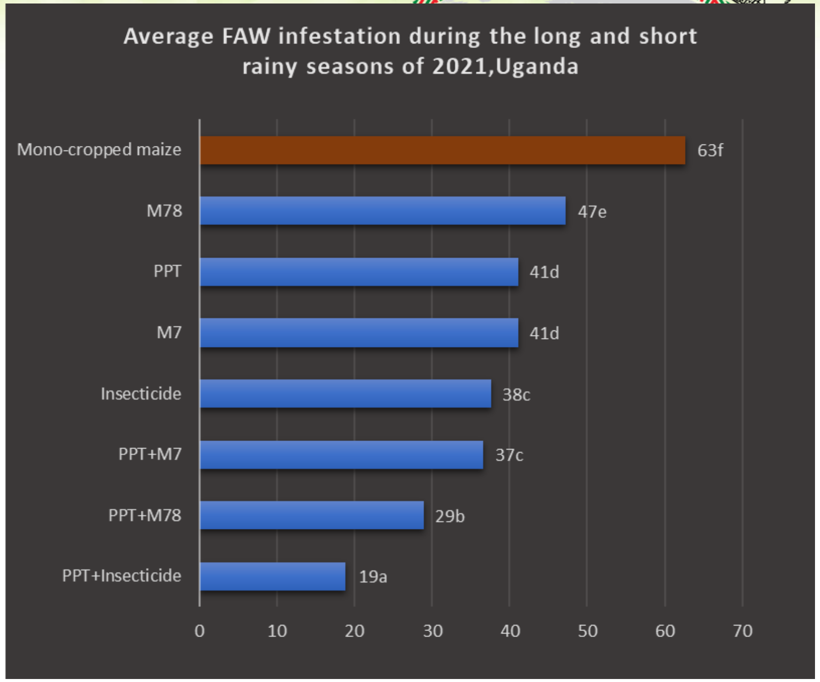
An on-station and on-farm validation trial conducted in Uganda

The treatments

1) M7,
2) M78,
3) Climate-smart PPT
4) M78 + PPT,
5) M7 + PPT,
6) Insecticide control,
7) PPT + insecticide,
8) Mono-cropped maize

Trial setup

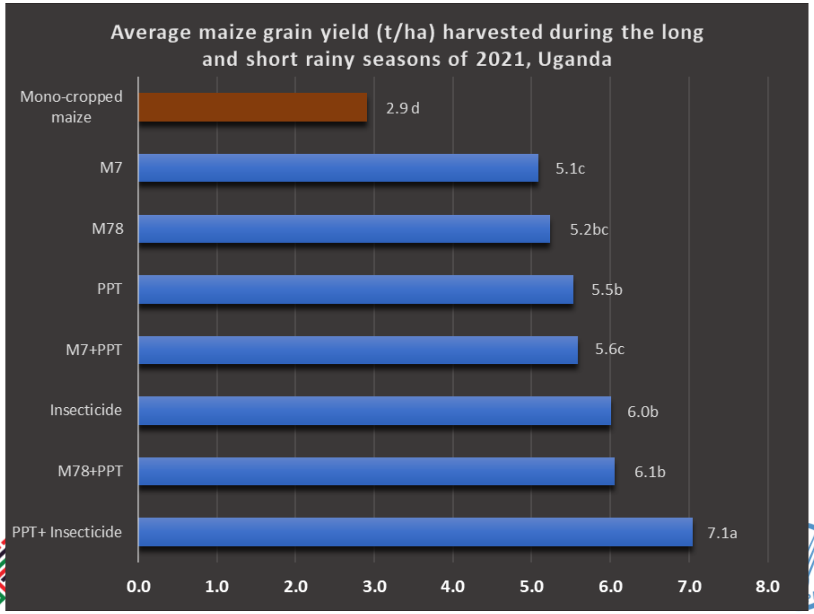
1) Treatments replicated 3 times RCBD at the station and farmer as replicate on-station.
2) Treatment applied at 3, 6, and 9 WAP



The findings

1) The biopesticide treatments reduced the FAW infestation significantly compared with mono-cropped maize
2) The yield obtained from different treatments significantly differed from mono-cropped maize.
3) The combined effect of Biopesticides and PPT were more effective in enhancing the maize yield

4) If treatments were applied based on FAW abundance not with fixed dates, the impact of the biopesticide would have been better



Food and Agriculture Organization of the United Nations

icipe

Key points to consider in biopesticides or mycoinsecticides development

- ✓ Biology & Ecology of the pest & the biocontrol agent
- ✓ Interactions between the pest & other organisms – ***Non target effects***
- ✓ Availability & Accessibility of the biocontrol agent
- ✓ Easy to formulate and apply & can be easily incorporated into IPM strategies
- ✓ Sustainable & environmentally friendly
- ✓ Low production cost & Cost-effective applications
- ✓ Pathogenic & virulent to the pest
- ✓ UV-tolerant isolates & Develop products that meet farmers' needs
- ✓ Not detrimental to the non target agents / Natural enemies & Pollinators
- ✓ Commercialization networks establishment
- ✓ Shelf life and storage conditions

Formulations, packaging, applications and factors that affect the viability or efficacy of EPF

✓ Temperature
✓ UV
✓ Humidity

✓ Some chemical lures are also not compatible with fungal viability and virulence

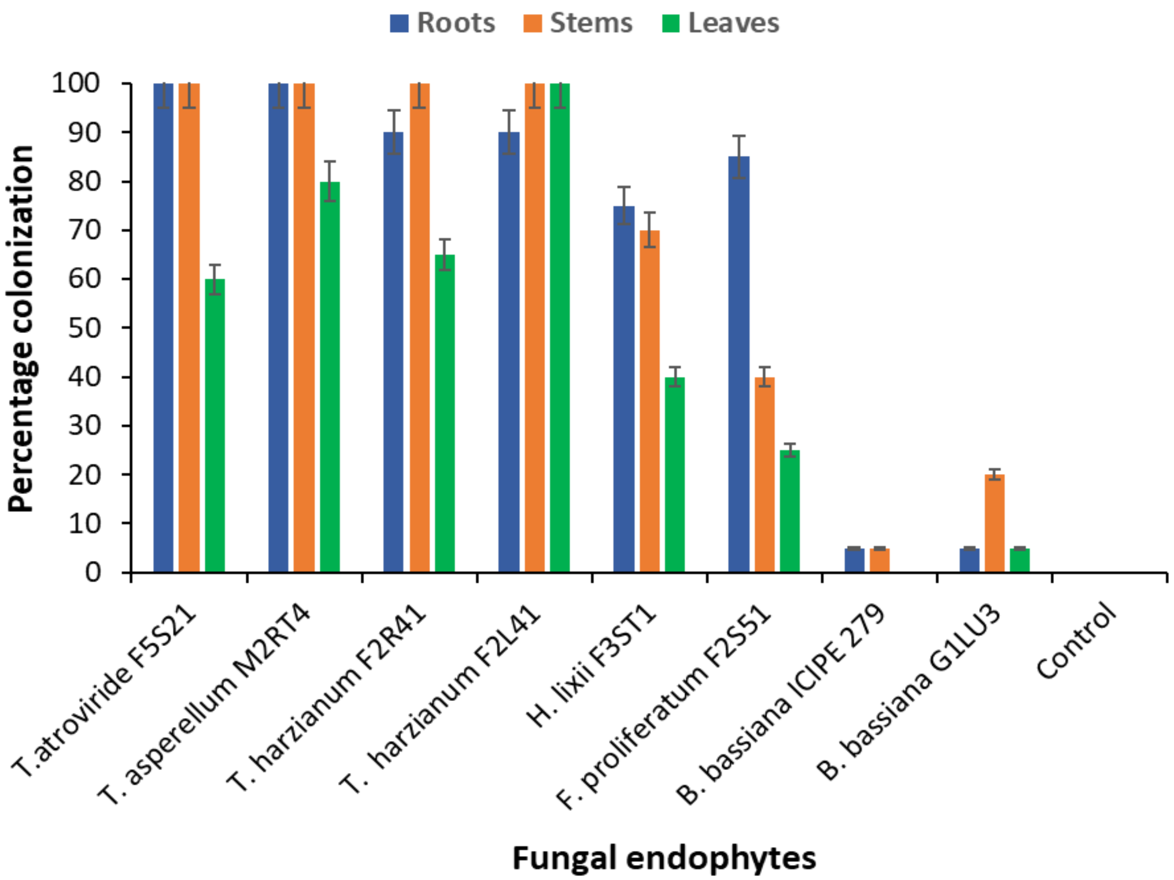
- Glycerin (0.1 %), nutrient agar (0.1% and molasses (0.5%) could be added to each formulation as protectants against UV light

- Ecological engineering could also be explored to overcome environmental factors

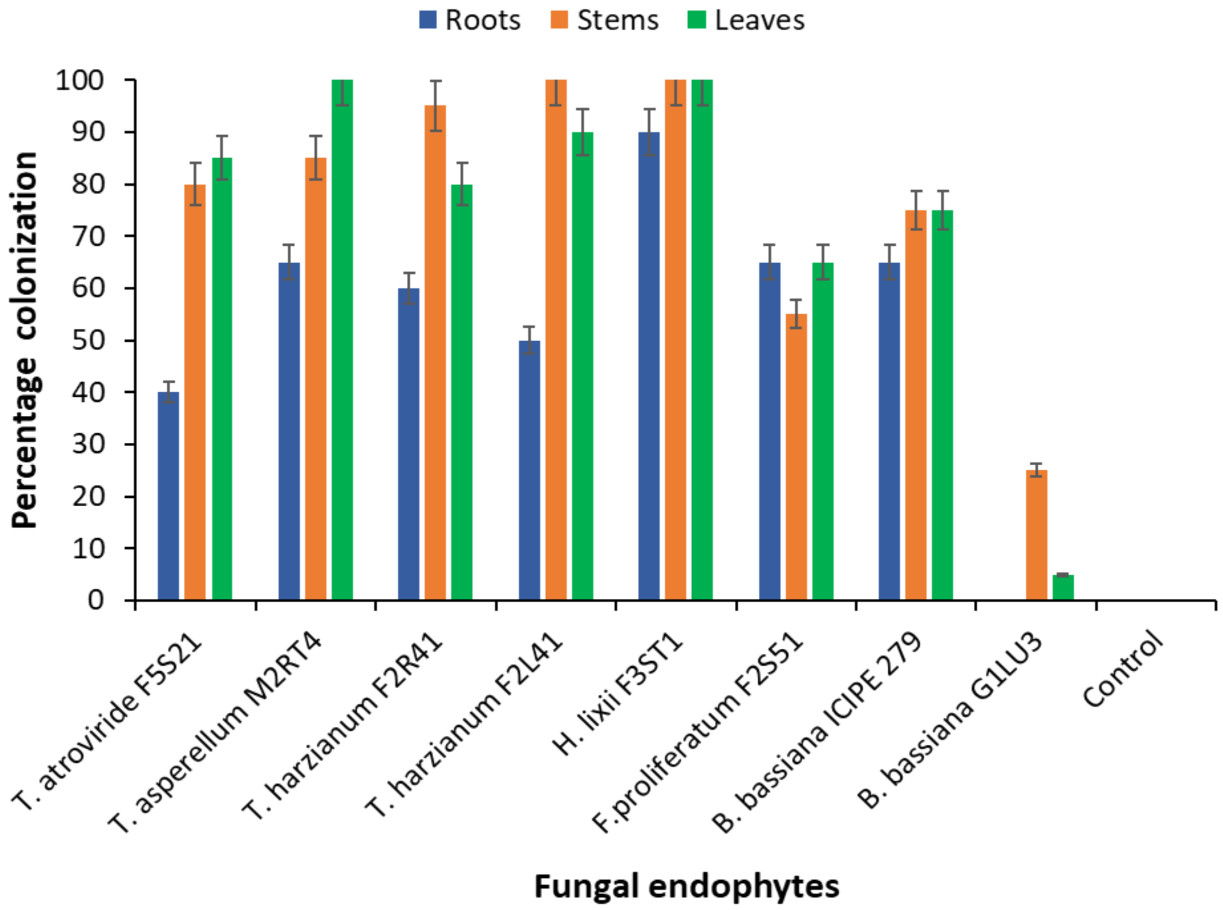
- Endophytes could overcome environmental abiotic challenges associated with EPF applications

- Genetic engineering provides useful strategies to either increase fungal virulence or enhance fungal resistance to different stress factors - (Virulence & Environmental stability)

Endophytes for PGP & FAW management

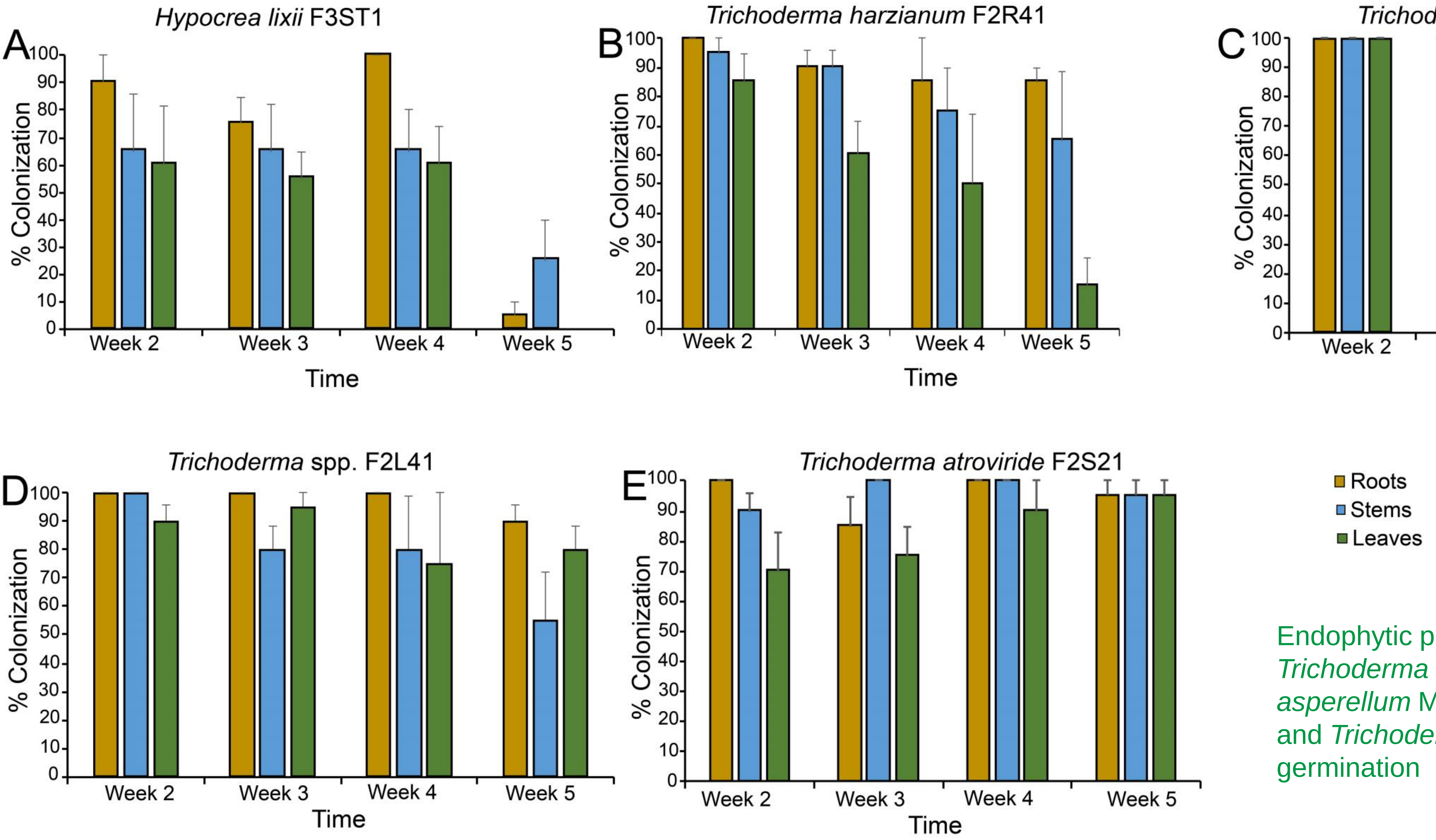


Endophytic colonization of maize seedlings through seed inoculation



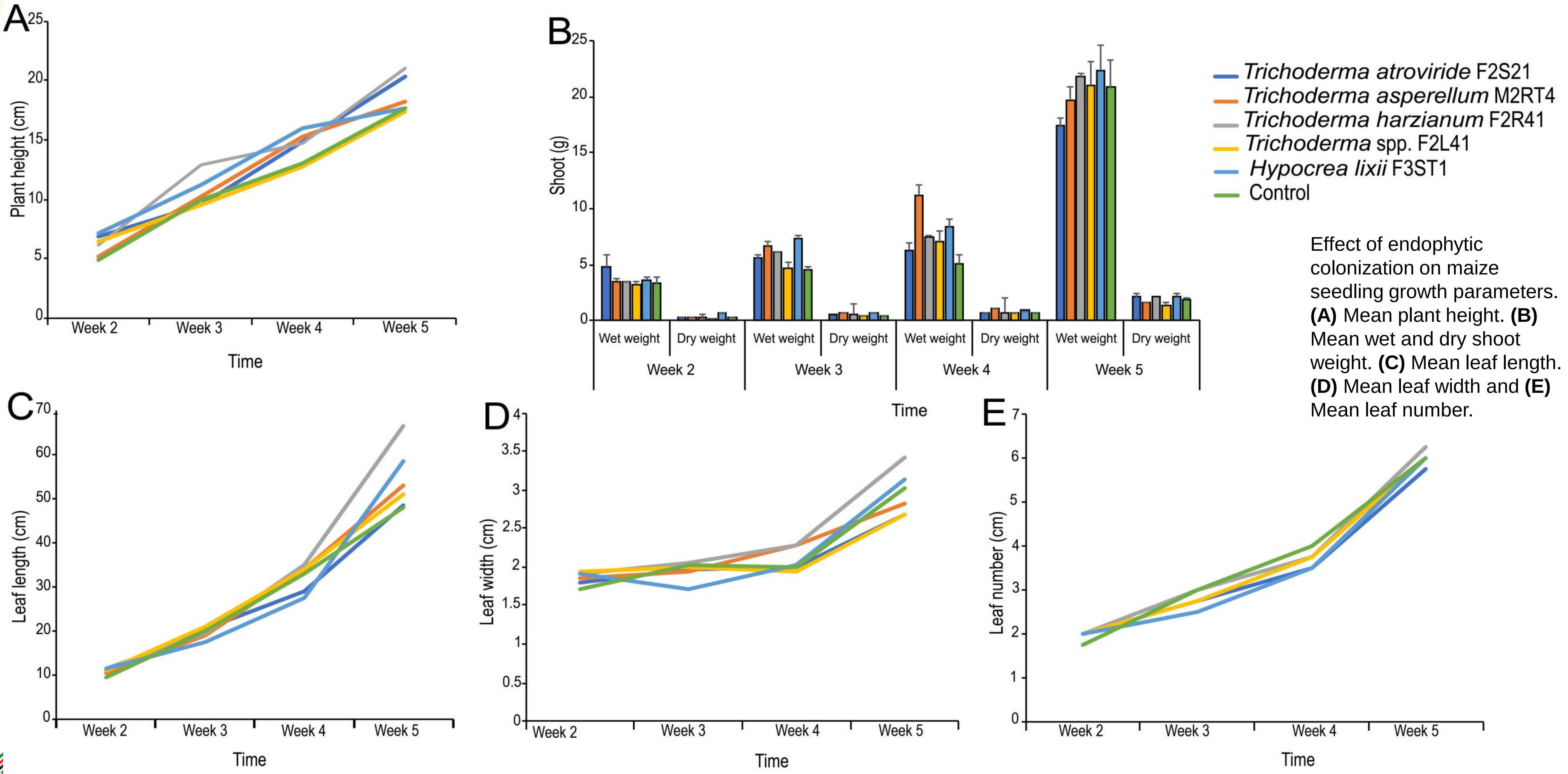
Endophytic colonization of maize seedlings through foliar application

Endophytes colonization persistence



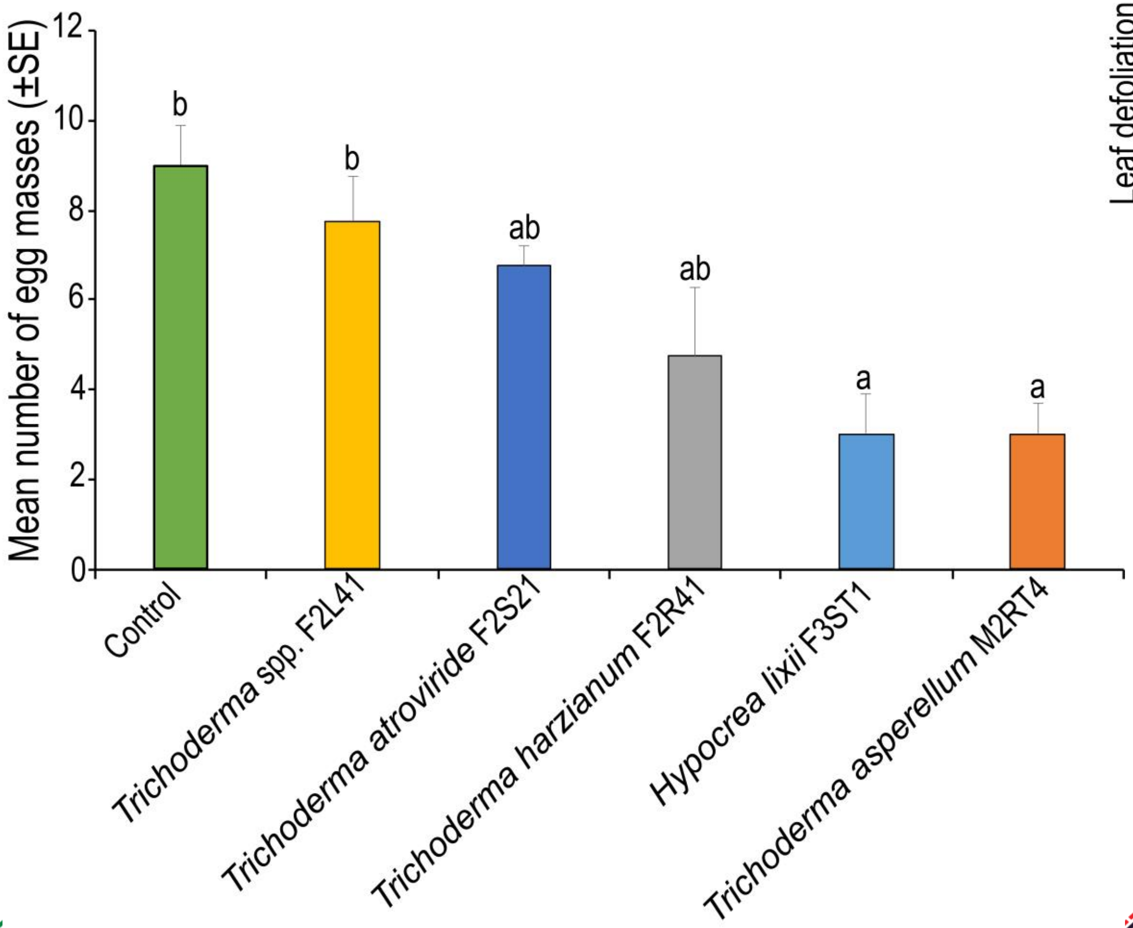
Endophytic persistence of *Hypocrea lixii* F3ST1, *Trichoderma harzianum* F2R41, *Trichoderma asperellum* M2RT4, *Trichoderma* spp. F2L41, and *Trichoderma atroviride* F2S21 5 weeks post-germination

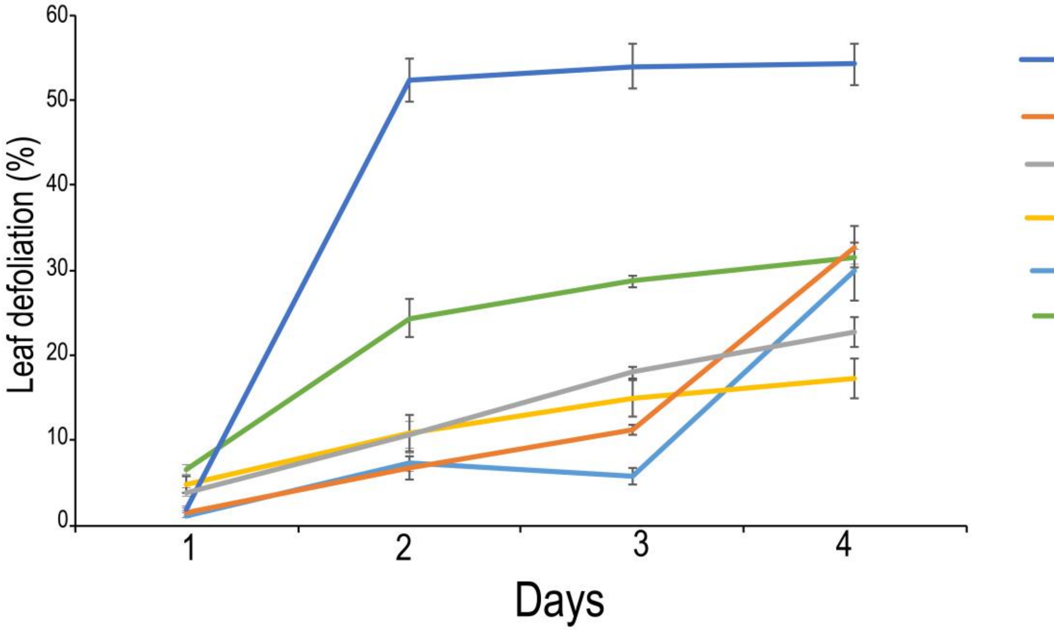
Plant growth promotion parameters



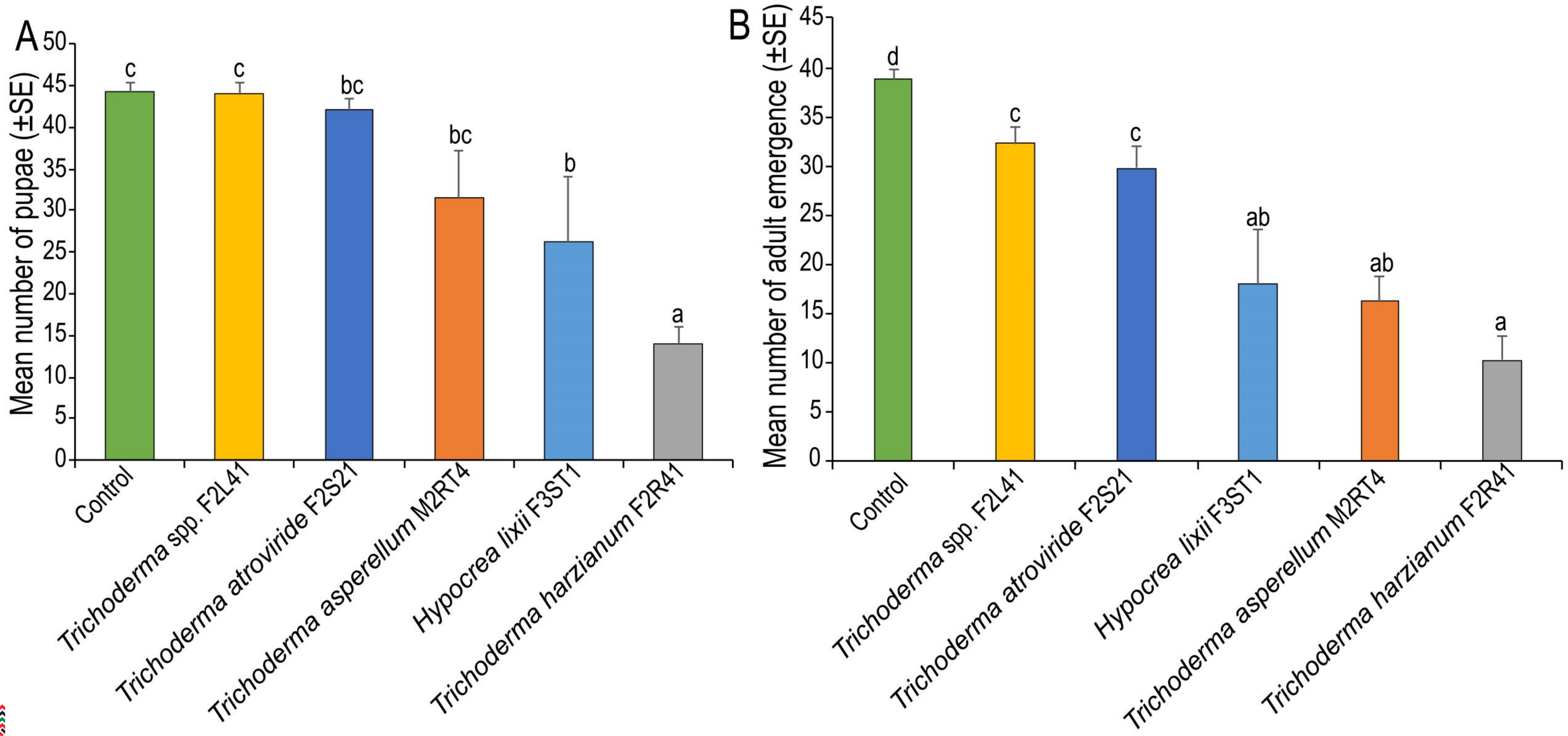
Effect of endophytic colonization on maize seedling growth parameters. **(A)** Mean plant height. **(B)** Mean wet and dry shoot weight. **(C)** Mean leaf length. **(D)** Mean leaf width and **(E)** Mean leaf number.

Endophytes effects on reproduction traits and feeding/defoliation



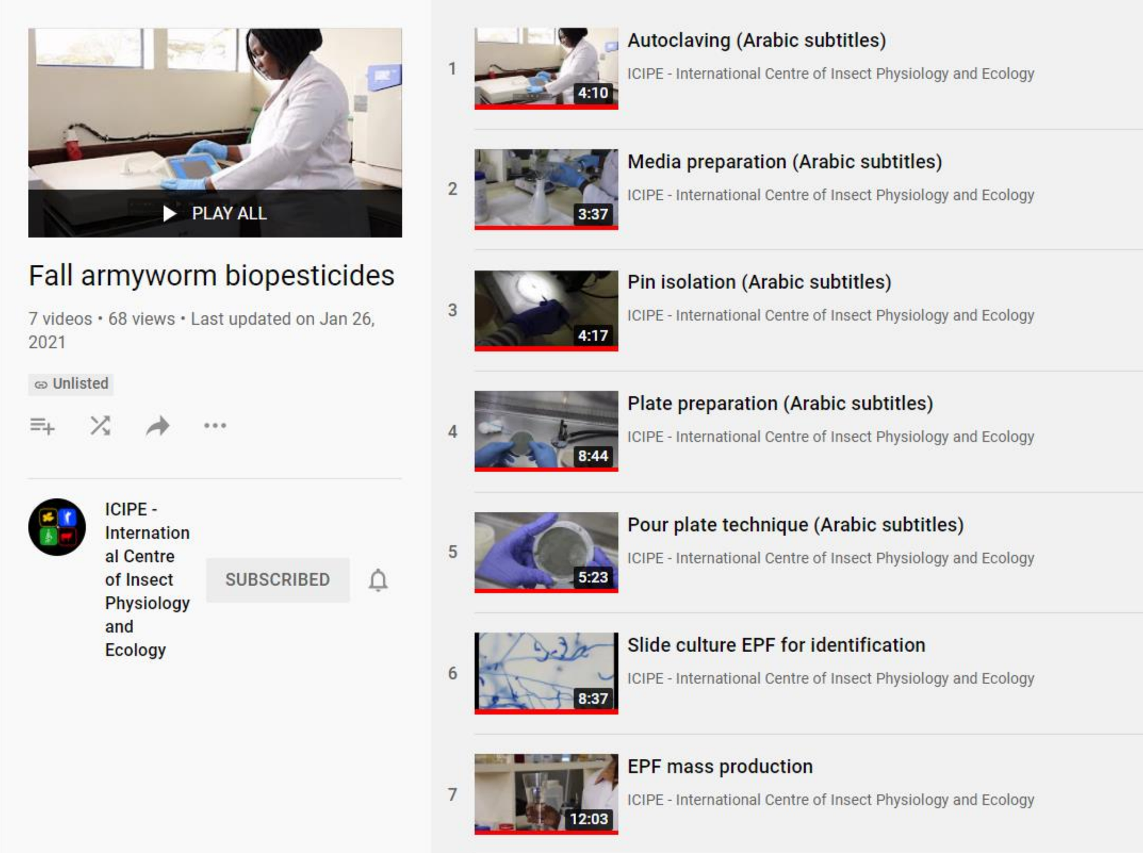


Endophytes effects on pupation and adult emergence



Building capacity of production entomopathogenic fungi

logical Control and
n Biological Control



Video-tutorial on basic entomopathological procedures and fungus production

Business incubation for small-scale farmers on biopesticide production

Arthropod Pathology Unit, *icipe*, 21-27 March 2020

Training facility for small-scale production of entomopathogenic fungi

Food and Agriculture Organization of the United Nations

icipe

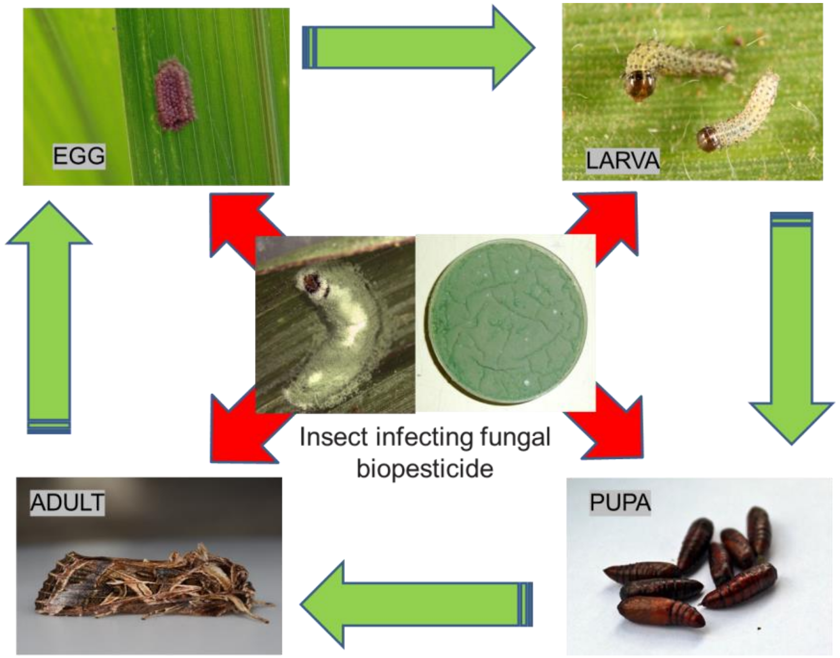
Expanding public-private-partnership for biopesticide scaling

Global Forum on Biological Control and Training Workshop on Biological Control

- Interaction between - regulatory authorities from Tanzania, Ethiopia, Kenya, Uganda and East African Community; 4 Biopesticides companies; National partners and researchers

- Strengthen **external partnerhips and collaborations** - from different part of the world

Achieve® & Detain®



Food and Agriculture Organization of the United Nations

icipe

Donor Acknowledgement

Global Forum on Biological Control and Training Workshop on Biological Control

Direct Financial Support to *icipe* from:-

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Sida

Foreign, Commonwealth & Development Office

Government of Kenya

Federal Democratic Republic of Ethiopia

African Union · ASI · AWARD · Australian Government, Australian Centre for International Agricultural Research · Austraining International · Bayer · Bertha Foundation · Bill & Melinda Gates Foundation · BBSRC · Government of the Republic of Benin · Government of Burkina Faso

British Council Institutional Links · Newton Fund · BioInnovate Africa · biovision · Biovision Africa Trust · Cambridge Africa · BMZ Federal Ministry for Economic Cooperation and Development · CIM Centre for International Migration and Development · cirad · Government of Côte d'Ivoire · Conservation International · CNHR Consortium for National Health Research

CS&S Code for Science & Society · DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service · DANIDA · DFG Deutsche Forschungsgemeinschaft · European Union · ECC-SDCOH · Embrapa · ETH zürich · FAO · FiBL · Ford Foundation · FNSNF

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH · Government of Ghana · Google.org · Grand Challenges Canada · IAEA · IDRC CRDI · IFAD Investing in rural people · IFS International Foundation for Science · iie · impaxio · IRD Institut de Recherche pour le Développement · Innovate UK

IVCC · JRS Biodiversity Foundation · Fondation L'Oréal · Government of South Korea · JIRCAS · Keele University · mastercard foundation · Max Planck Institute for Chemical Ecology · The McKnight Foundation · Ministry for Foreign Affairs of Finland · mozilla · Government of Mozambique · National Academy of Sciences

National Geographic Society · NIH National Institutes of Health · NRF Kenya National Research Fund · NSF · Netherlands Directorate-General for International Cooperation · NWO · Open Philanthropy · Pelum Association · R. Geigy-Stiftung · Russell IPM

Norad · The Rockefeller Foundation · The Royal Society · Government of Rwanda · RSS · Scottish Funding Council · Government of Senegal · switchafrica green · The World Bank · twas

UNEP · University of Glasgow · USAID From the American People · USDA · Vetenskapsrådet · VolkswagenStiftung · wellcome · World Federation of Scientists · World Health Organization · World Trade Organization · WSD

Food and Agriculture Organization of the United Nations · icipe

Thank you

Co-organized by

Food and Agriculture Organization of the United Nations

icipe

Supported by

EUROPEAN UNION

USAID FROM THE AMERICAN PEOPLE

german cooperation DEUTSCHE ZUSAMMENARBEIT

Implemented by giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH