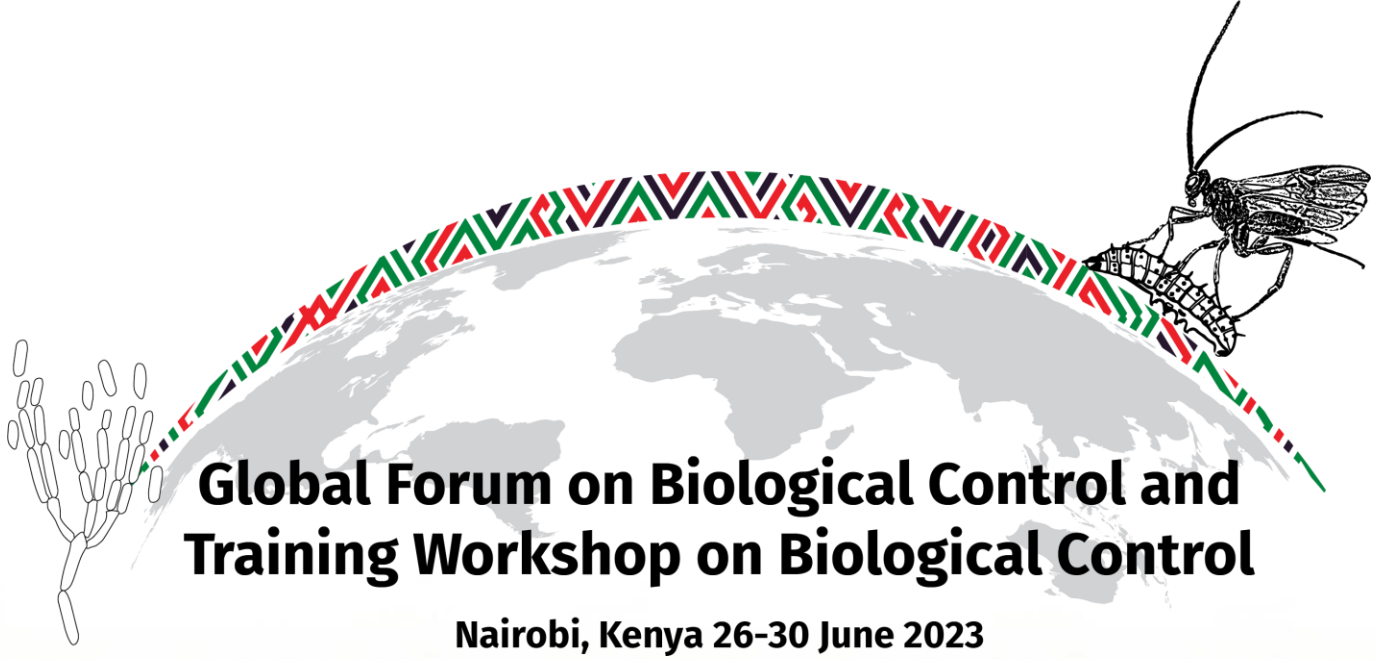


Global Forum on Biological Control and
Training Workshop on Biological Control

Nairobi, Kenya 26-30 June 2023

Biopesticide R&D, production and commercialization pathways

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

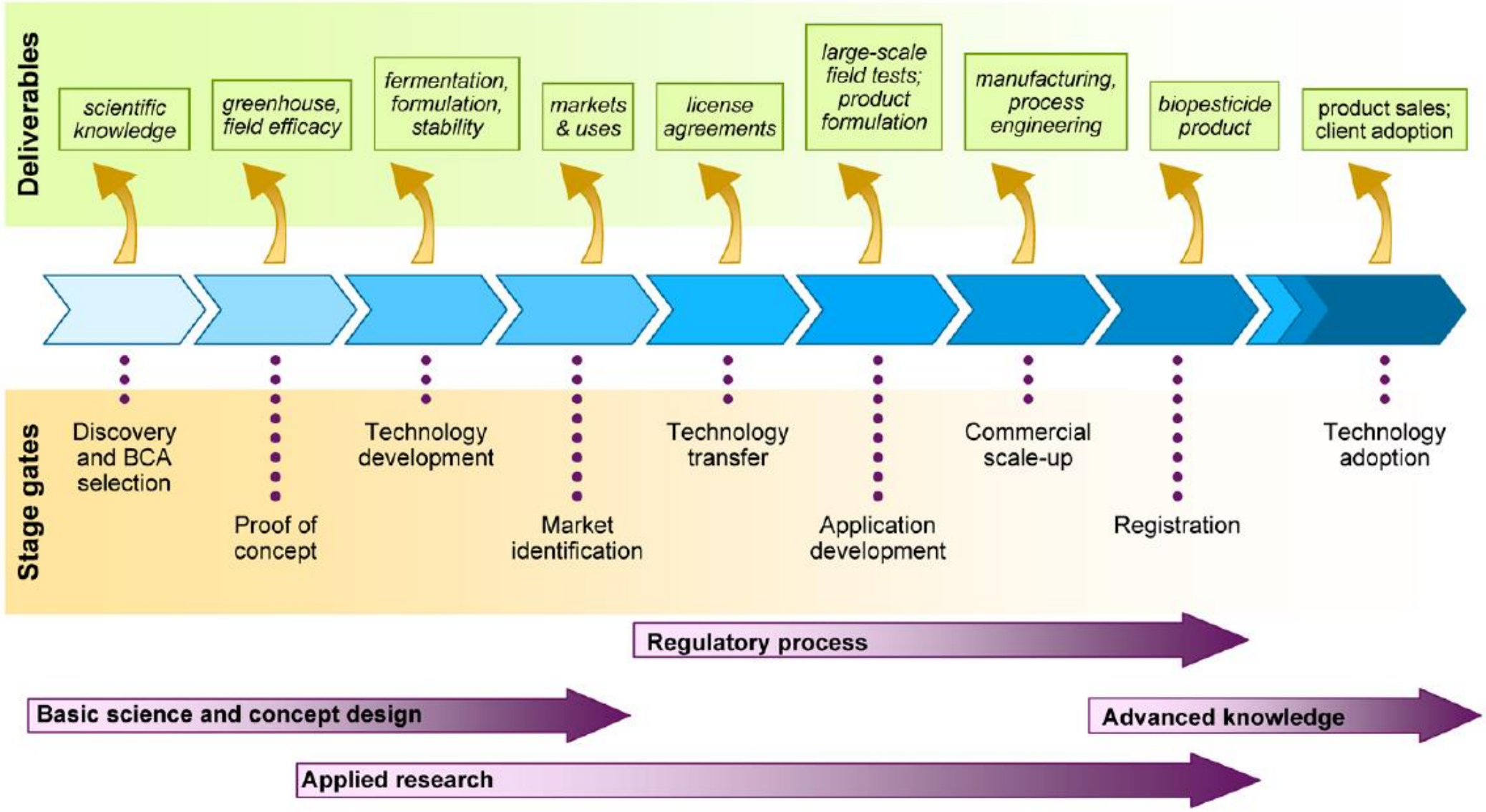
giz

Arthropod Pathology Unit

Global Forum on Biological Control and Training Workshop on Biological Control

- 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

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

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*

Plant pests

Global Forum on Biological Control and Training Workshop on Biological Control

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

- Aphids

Metarhizium 78

- Mites

Metarhizium 7

- Ticks

Metarhizium 69

- Fruit flies
- Thrips
- Mealybugs

realIPM biobest SUSTAINABLE CROP MANAGEMENT

In partnership with *icipe*

Outreach for commercialized biopesticides

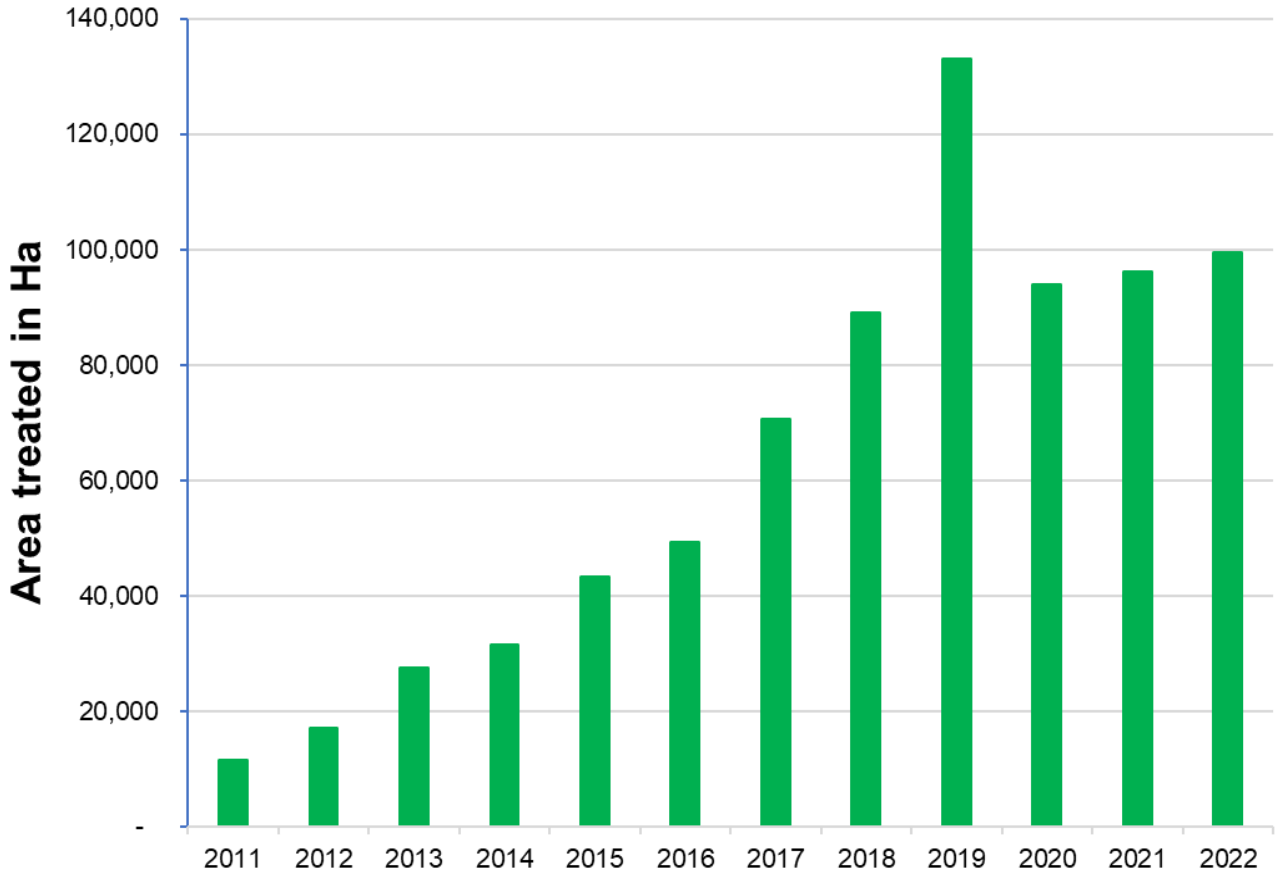
Registration status - Registered in 13 countries

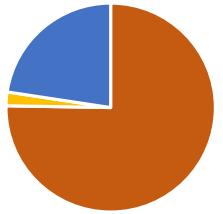
realIPM biobest SUSTAINABLE CROP MANAGEMENT

Scaling up of icipe' s commercialized biopesticides

Global Forum on Biological Control and Training Workshop on Biological Control

Acreage of biopesticides use





Met 69 Met62 Met78

Building private sector partnerships

realIPM

Russell IPM
INTEGRATED PEST MANAGEMENT

HEAL
BIOTECH & AGRICULTURE

éléphant vert

Food and Agriculture Organization of the United Nations

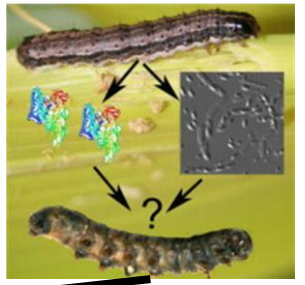
icipe

Building on icipe' s biopesticide experience

Identification of effective biopesticides against the invasive FAW

Development of a biopesticide products for all stages for FAW

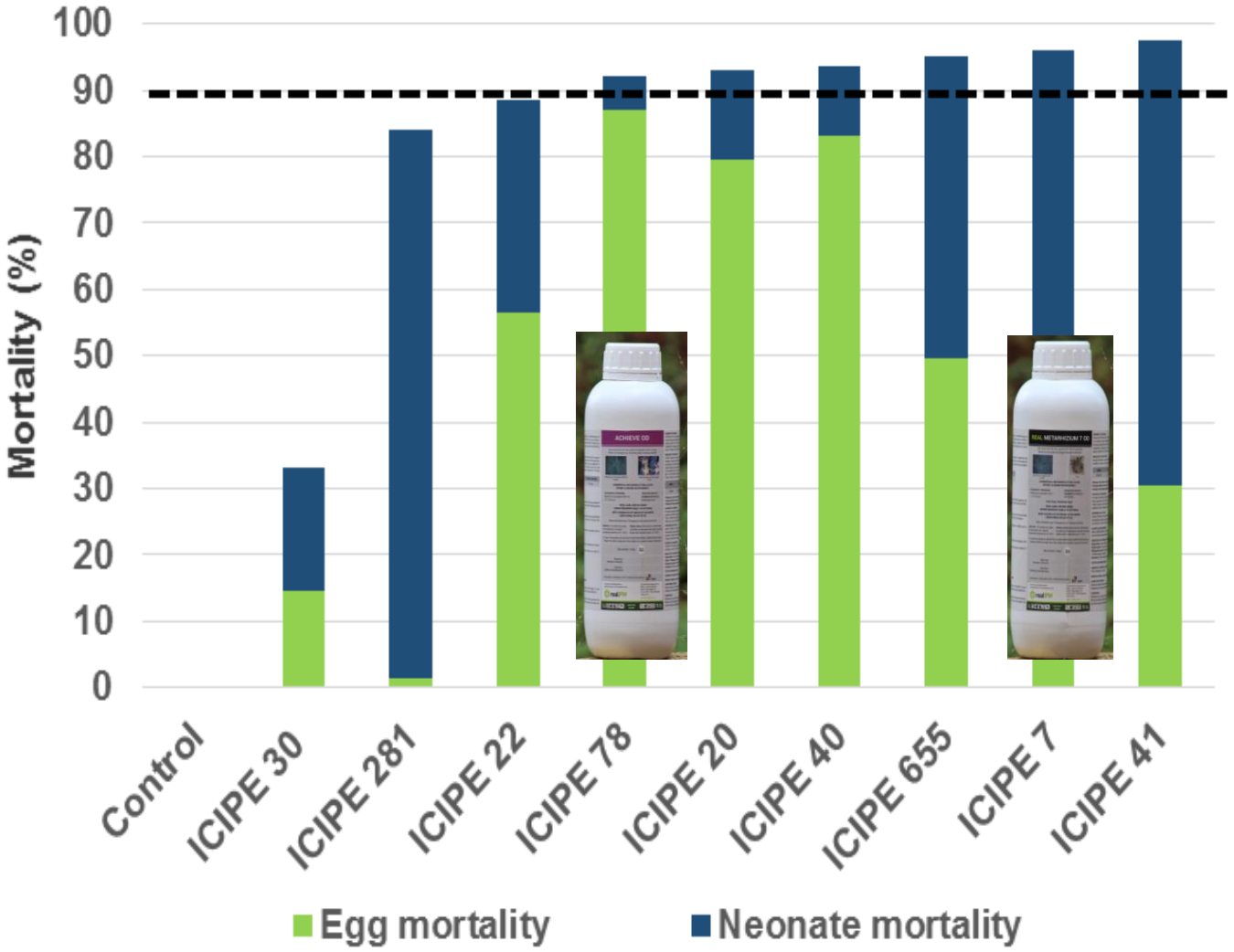
Insect viral diseases – eg.
Baculoviruses



Insect bacterial diseases – eg.
Bacillus thuringiensis

Insect fungal diseases – eg.
Metarhizium anisopliae;
Beauveria bassiana

Efficacy of EPFs against FAW egg and newly emerged larvae



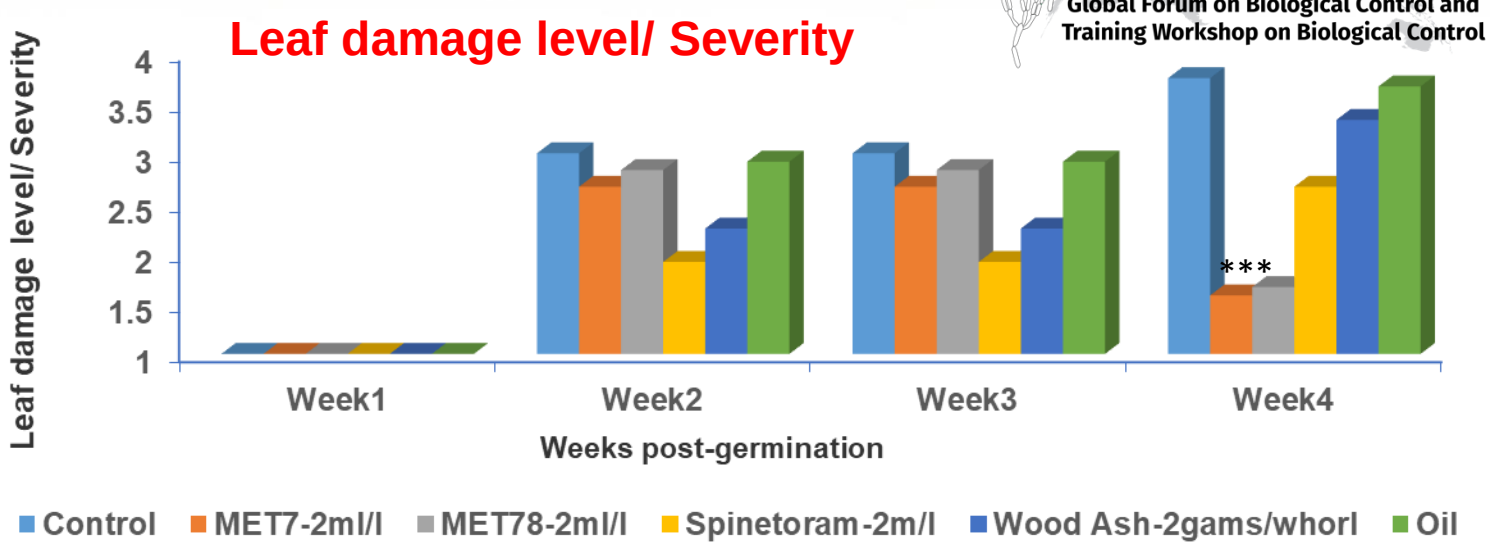
ORIGINAL CONTRIBUTION

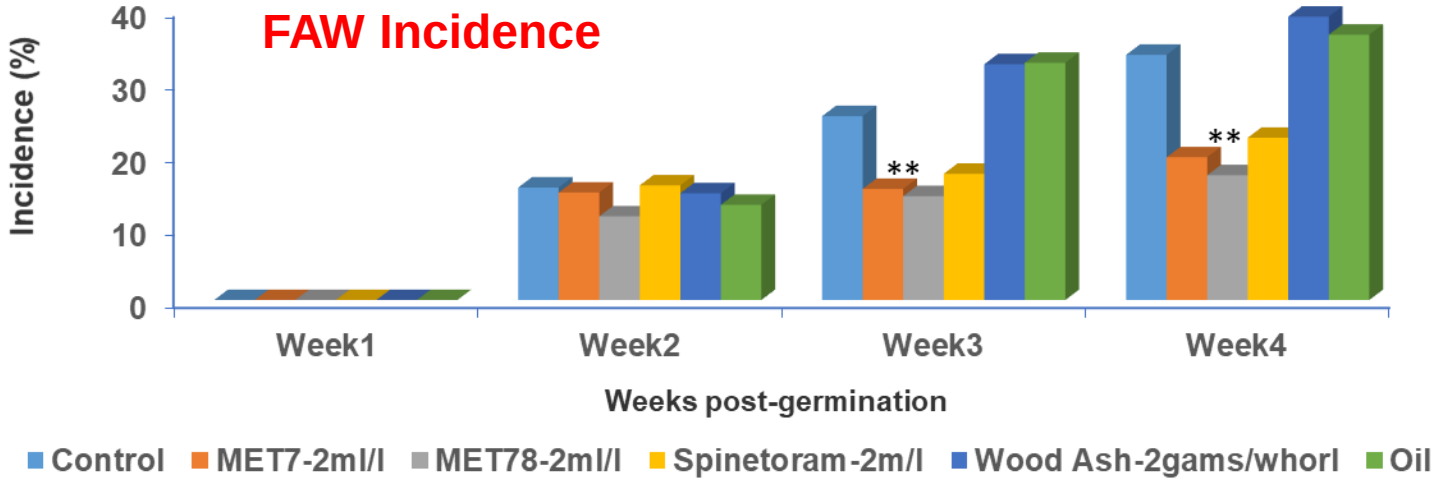
WILEY JOURNAL OF APPLIED ENTOMOLOGY

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

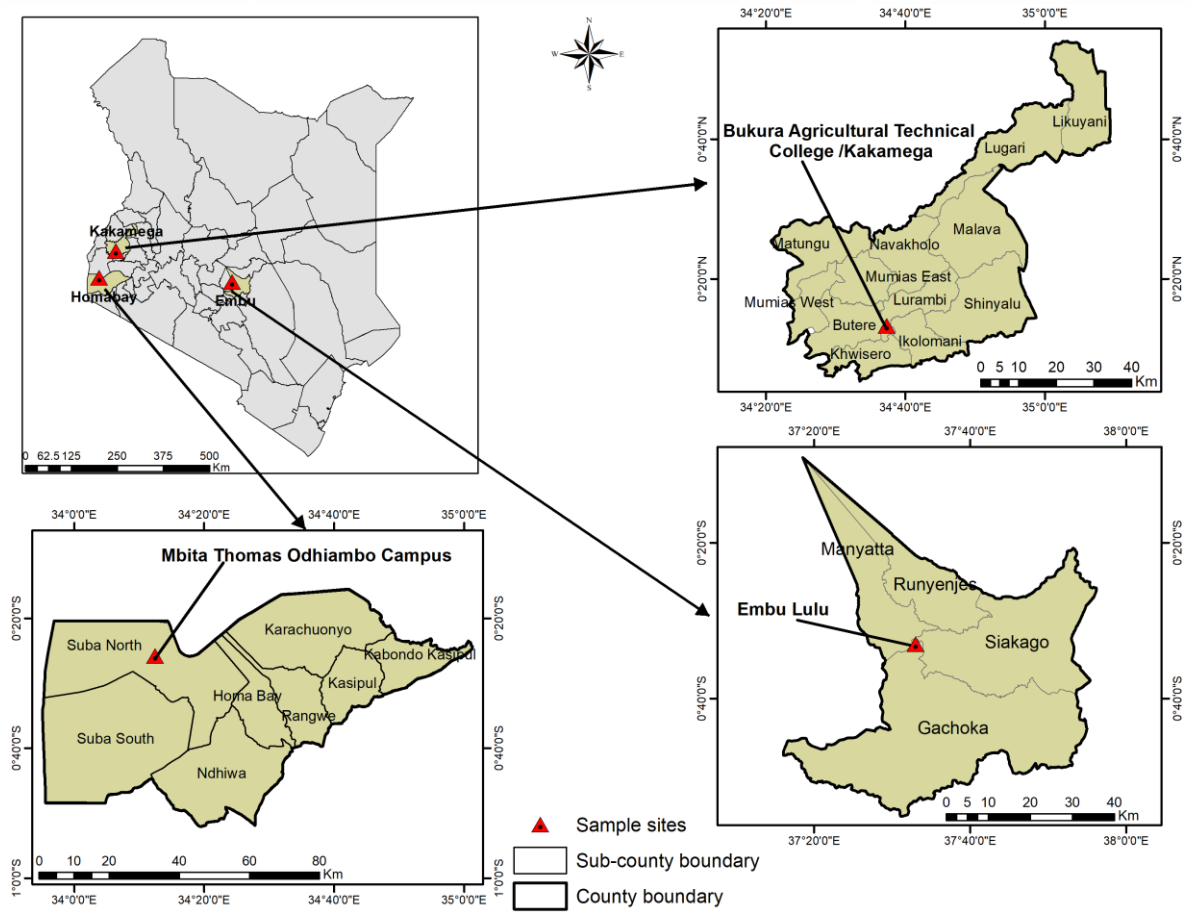
Field efficacy trial with ICIPE 7 & ICIPE 78 – Embu, Kenya





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

Global Forum on Biological Control and Training Workshop on Biological Control



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**

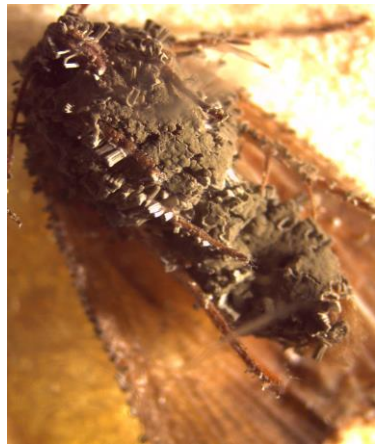
T1- Control (Water only as application) ; **T2-** Met 7 (Oil formulation); **T3-** Met 78 (Oil formulation); **T4-** Chemical (Radiant); **T5-** Wood ash; **T6-** Mixit (Oil only as application)

Food and Agriculture Organization of the United Nations

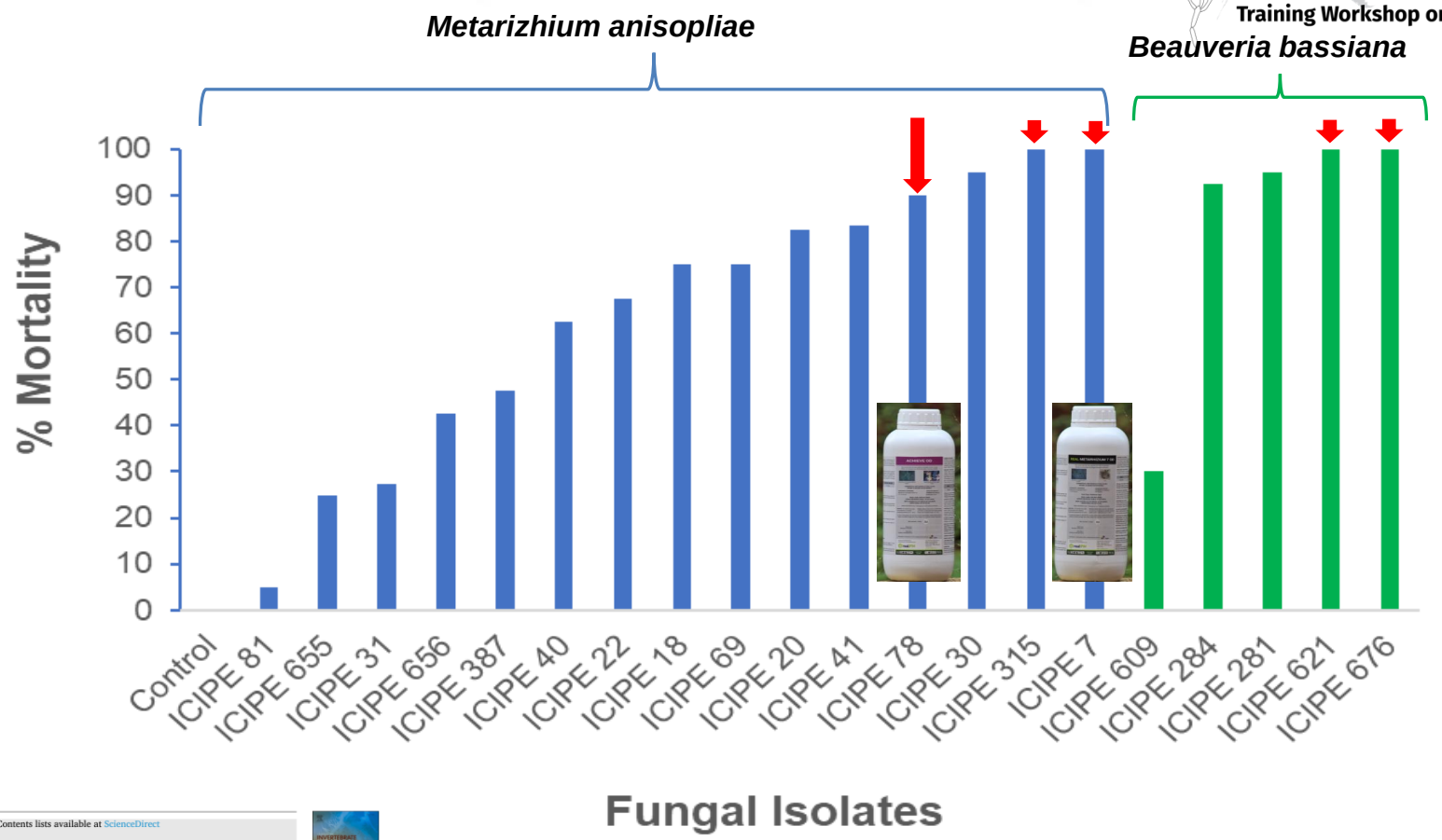
icipe

Efficacy of EPF on FAW adults

Healthy



Fungus-infected



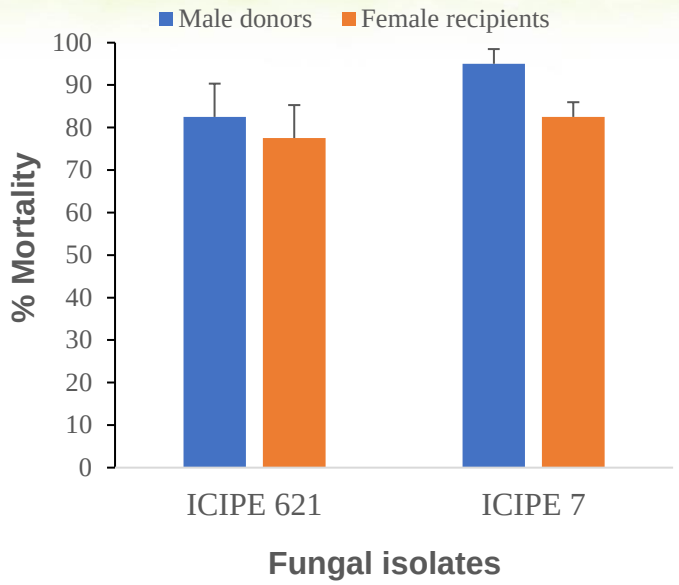

Contents lists available at ScienceDirect
Journal of Invertebrate Pathology
journal homepage: www.elsevier.com/locate/jip
ELSEVIER

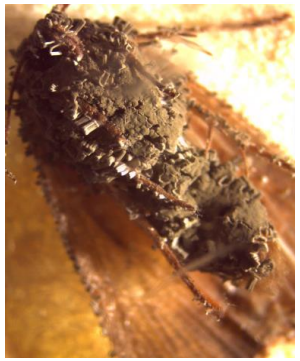
Combining insect pathogenic fungi and a pheromone trap for sustainable management of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

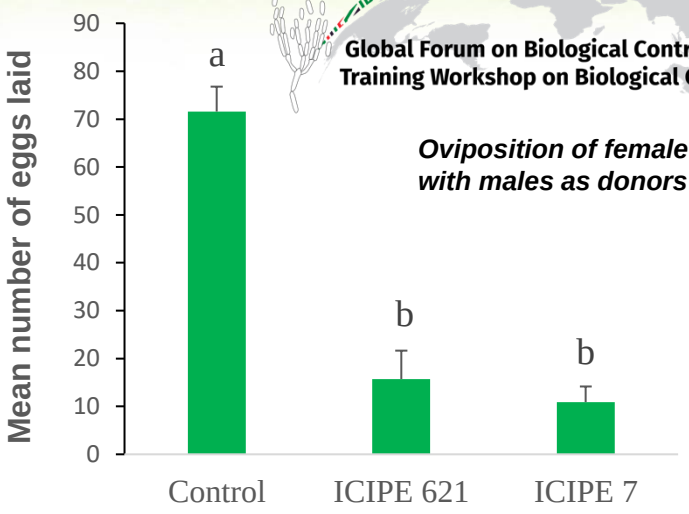
Komivi S. Akutse[a,*], Fathiya M. Khamis[a], Felicitas C. Ambele[a,b], Jane W. Kimemia[a], Sunday Ekesi[a], Sevgan Subramanian[a]

- ***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

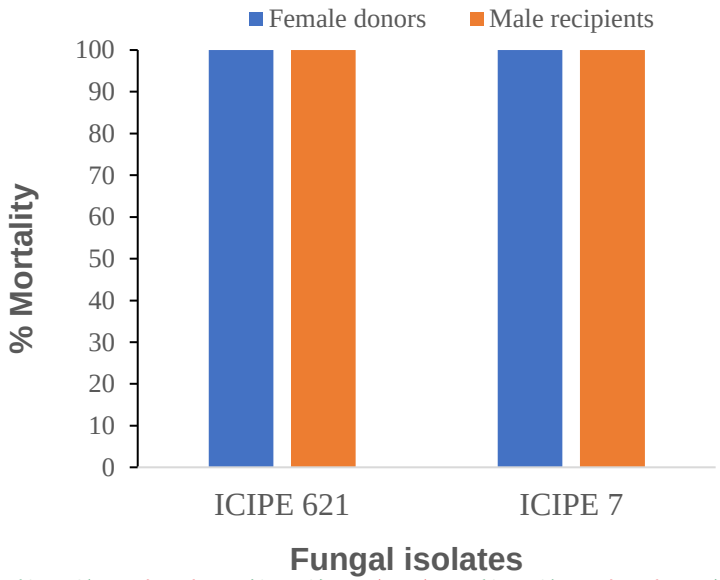




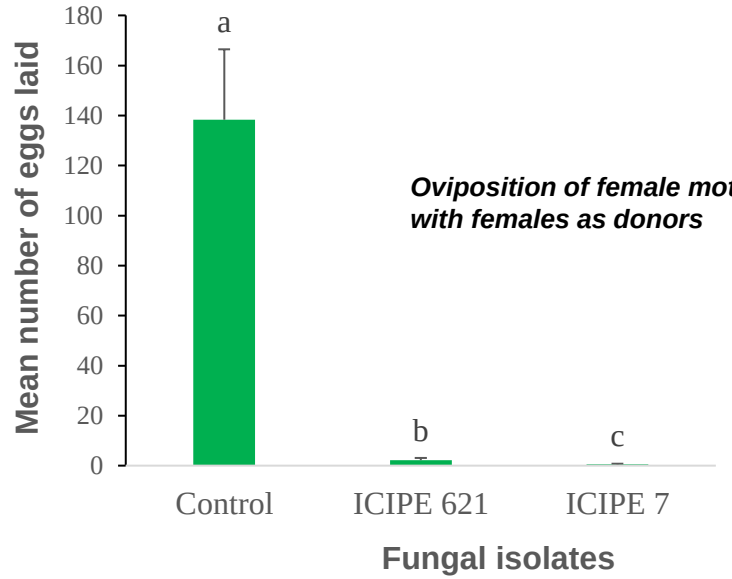


Global Forum on Biological Control and Training Workshop on Biological Control

Oviposition of female moths with males as donors



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



Oviposition of female moths with females as donors

Journal of Invertebrate Pathology 177 (2020) 107477

Contents lists available at ScienceDirect

Journal of Invertebrate Pathology

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

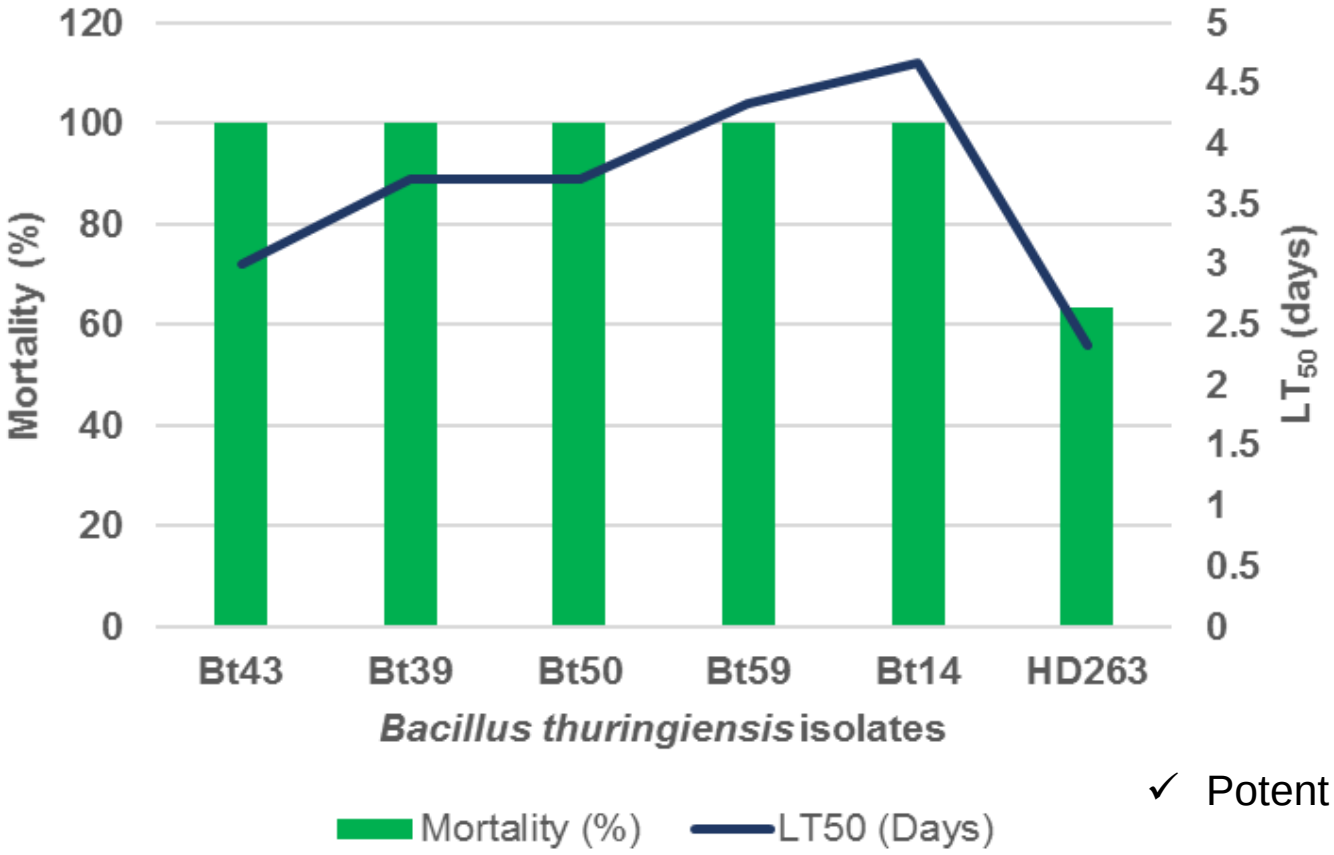
Combining insect pathogenic fungi and a pheromone trap for sustainable management of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

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.

R4D support for enhancing product effectiveness & Capacity building

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

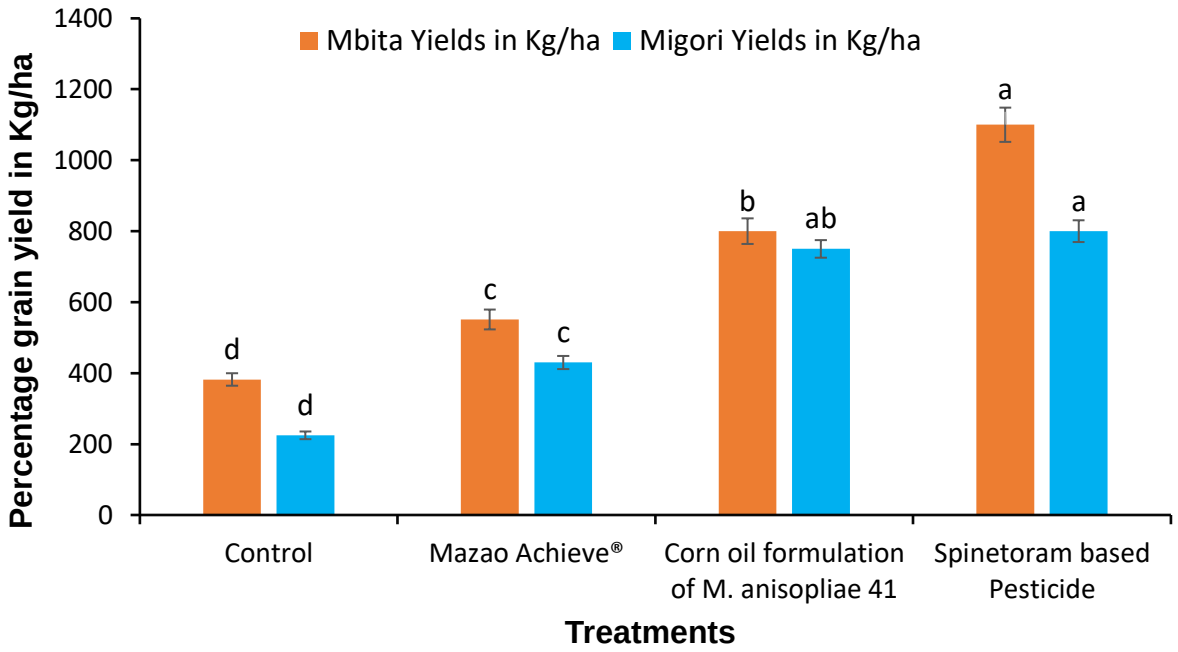
Parasitism rates obtained after indirect application of ICIPE 41 formulations

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

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

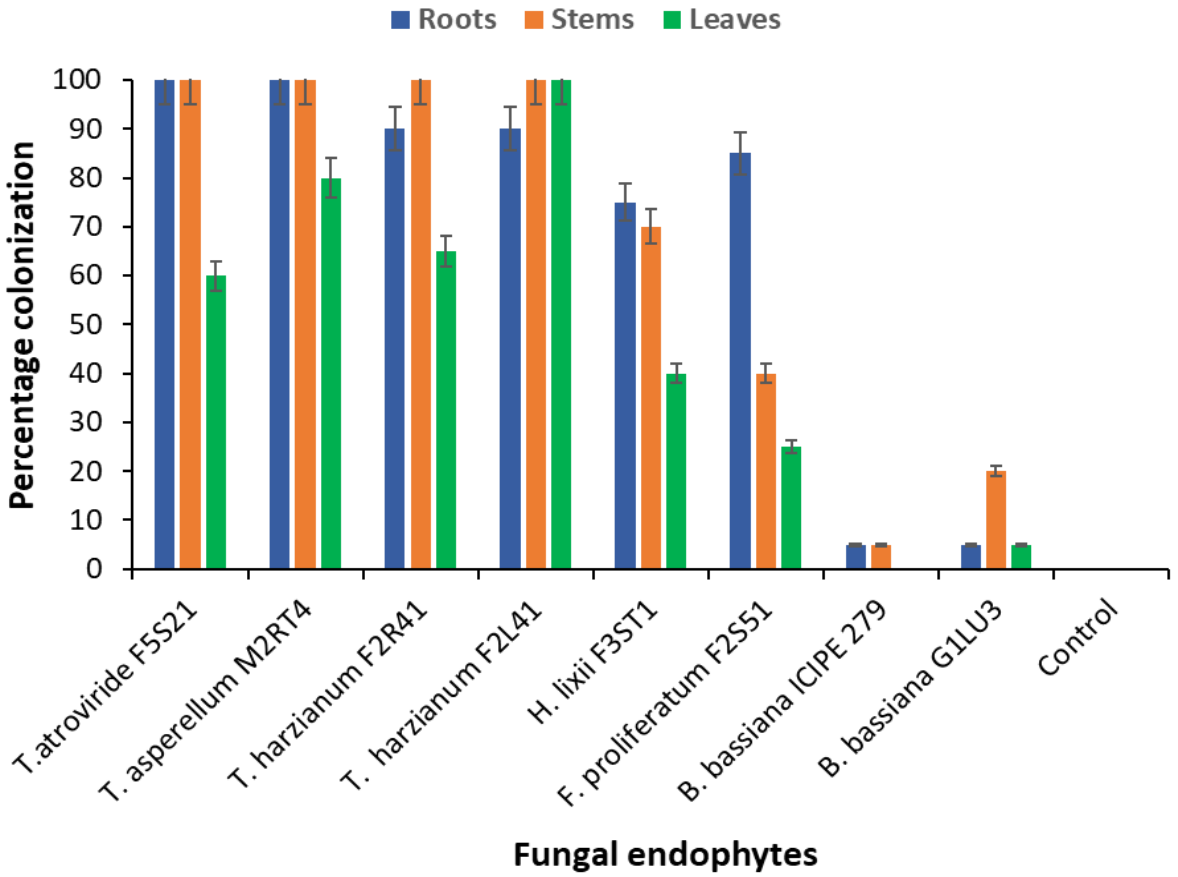


agronomy
MDPI
Article

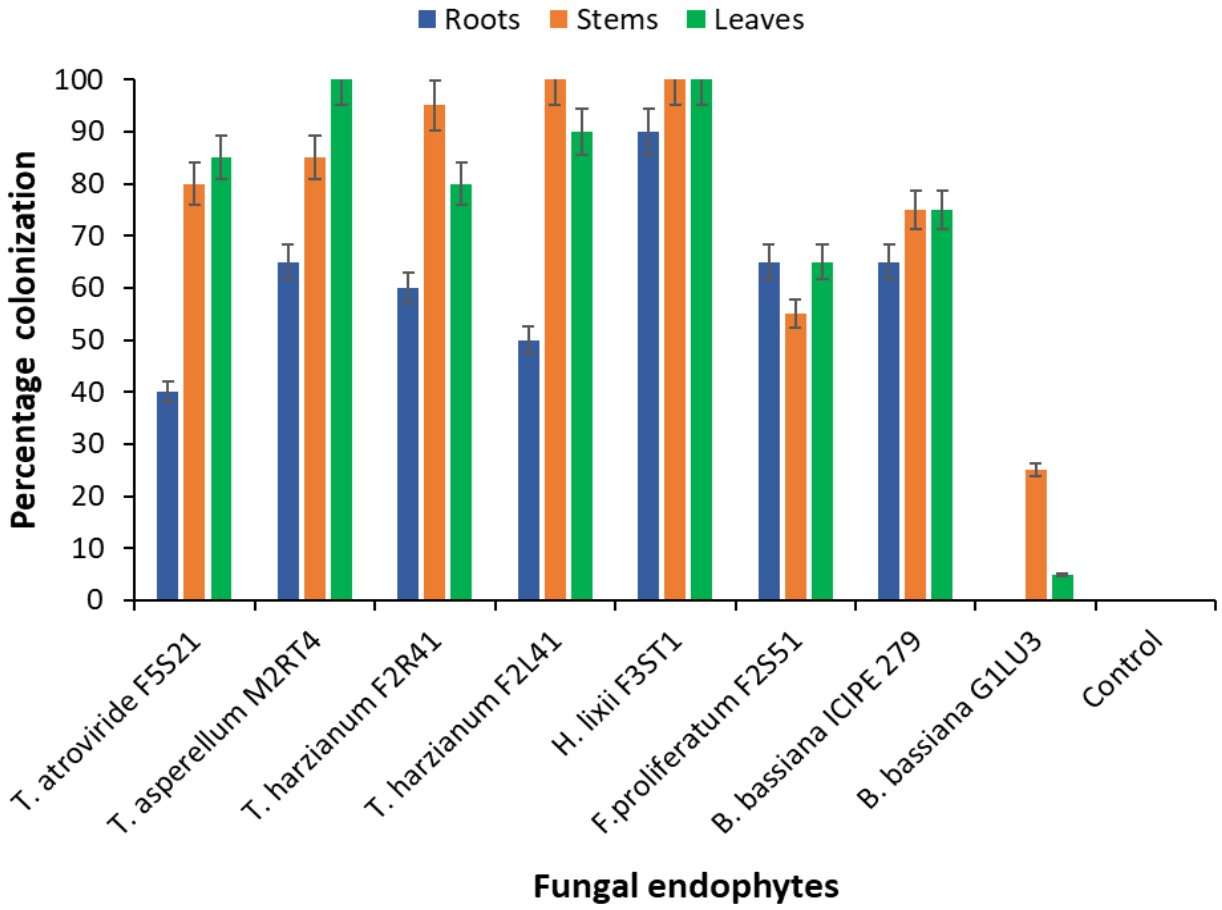
Performance of *Metarhizium anisopliae* Isolate ICIPE 41 in the Laboratory and Field in Comparison to Another Fungal Biopesticide and a Chemical Product to Sustainably Control the Invasive Fall Armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

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,*]

Endophytes for PGP & FAW management

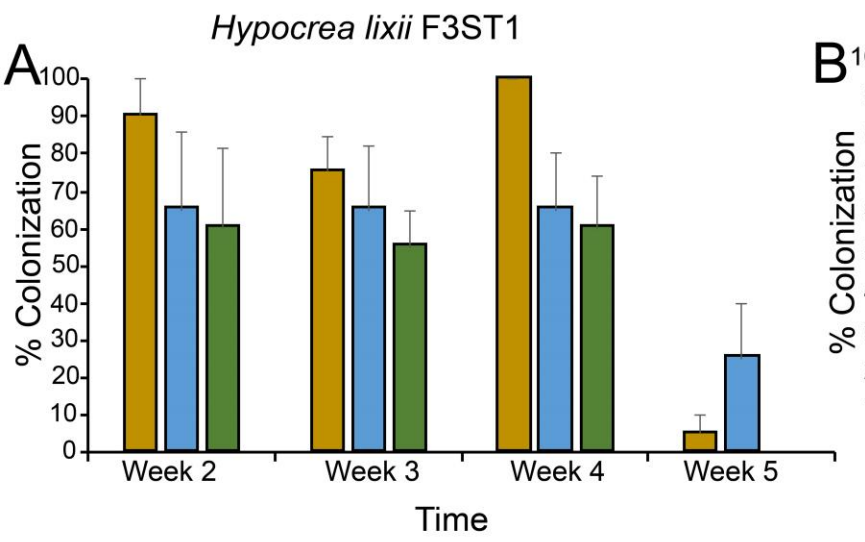


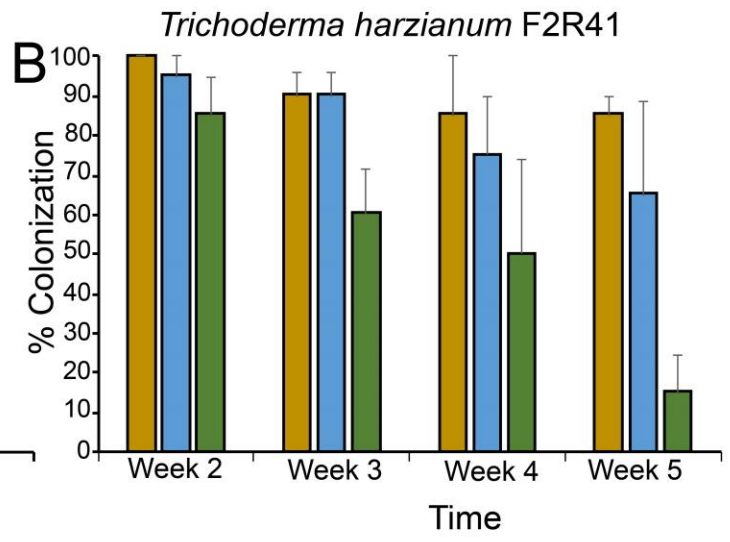
Endophytic colonization of maize seedlings through seed inoculation

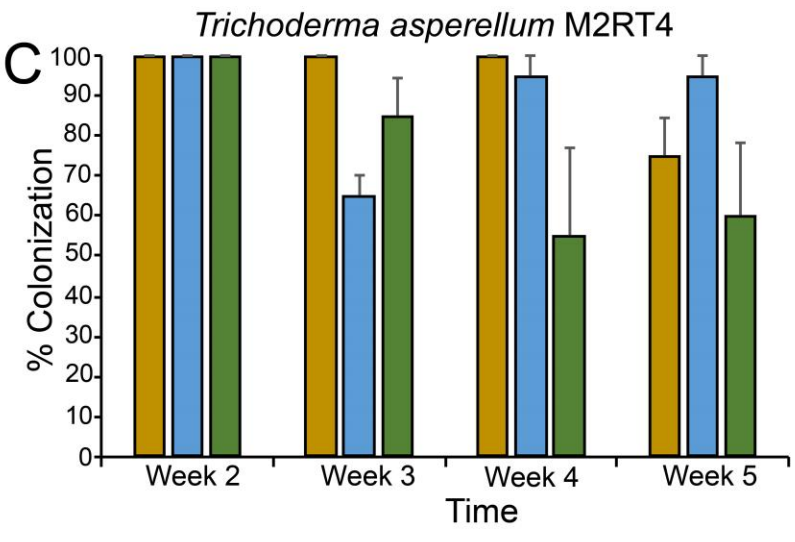


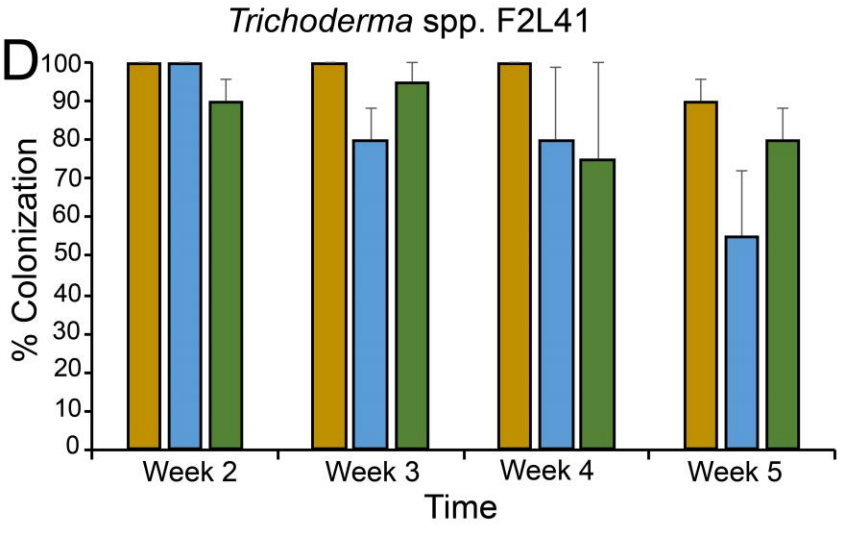
Endophytic colonization of maize seedlings through foliar application

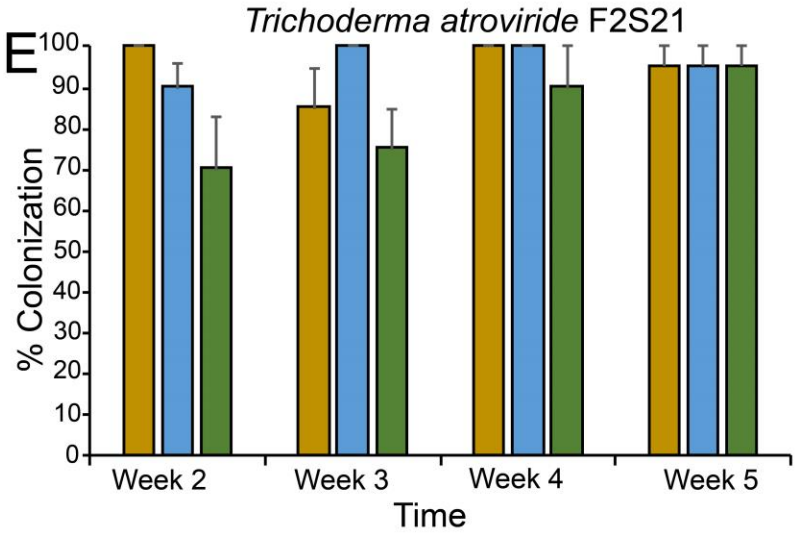
Endophytes colonization persistence

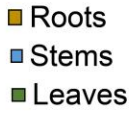






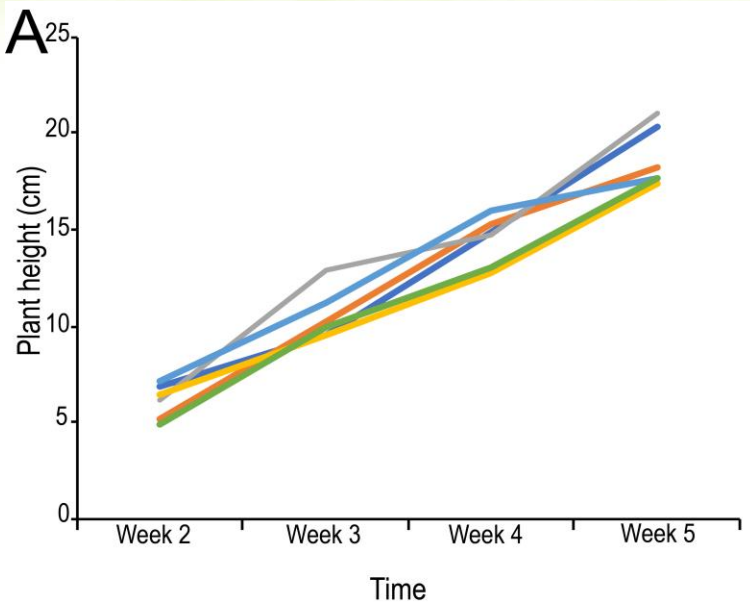


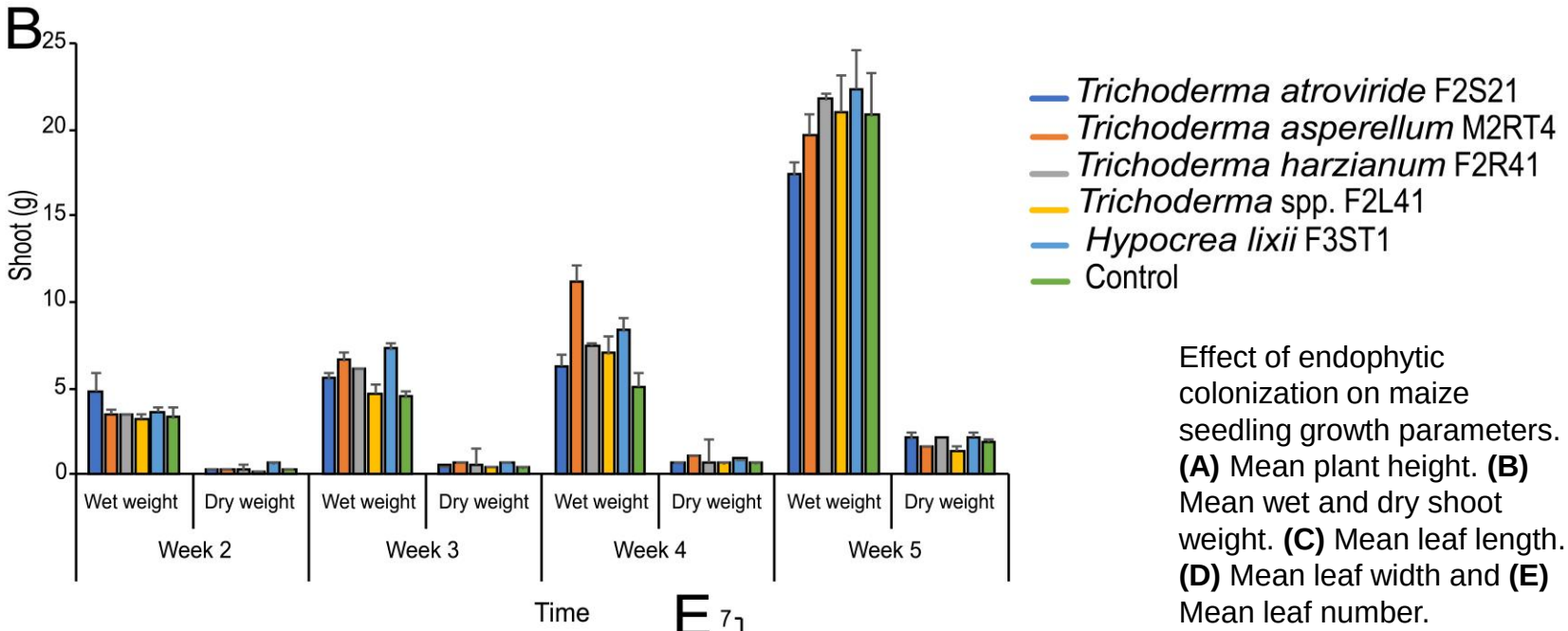




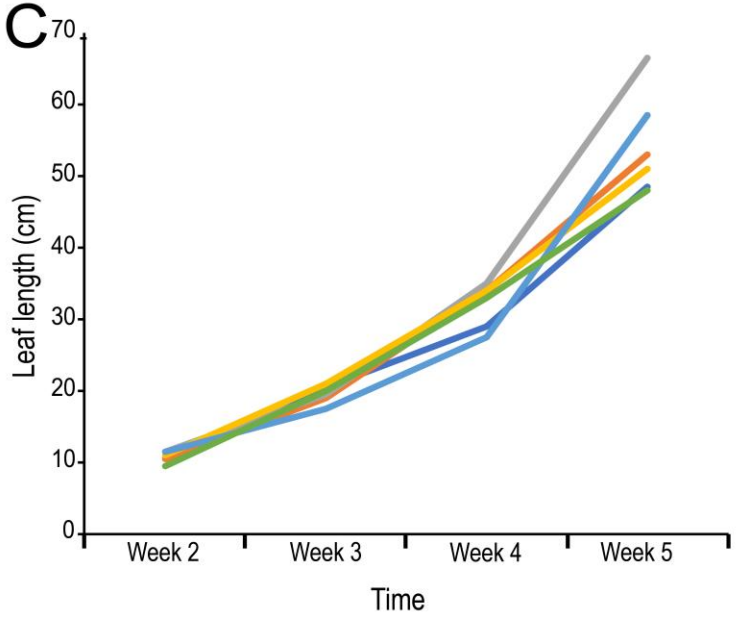
Endophytic persistence of *Hypocrea lixii* F3ST1, *Trichoderma harzianum* F2R41, *Trichoderma asperellum* M2RT4, *Trichoderma* spp. F2L41, and *Trichoderma atroviride* F2S21 5 weeks post-germination

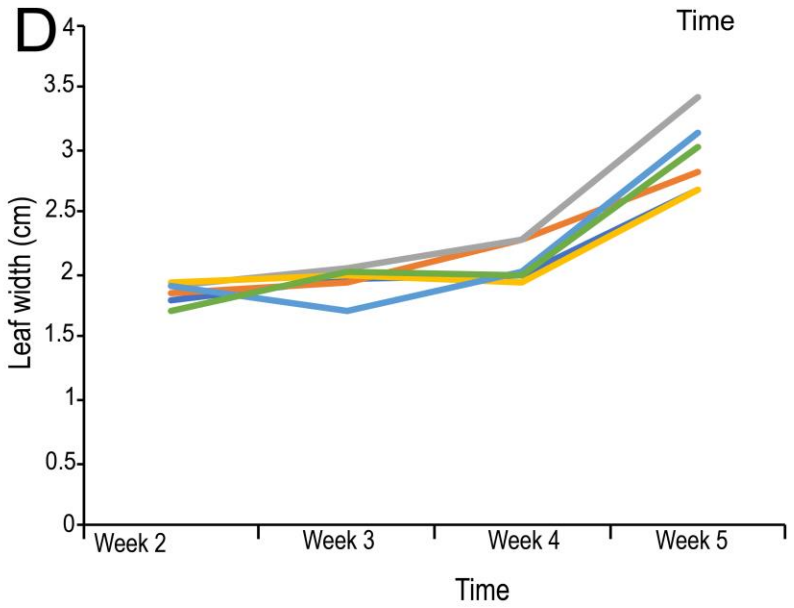
Plant growth promotion parameters

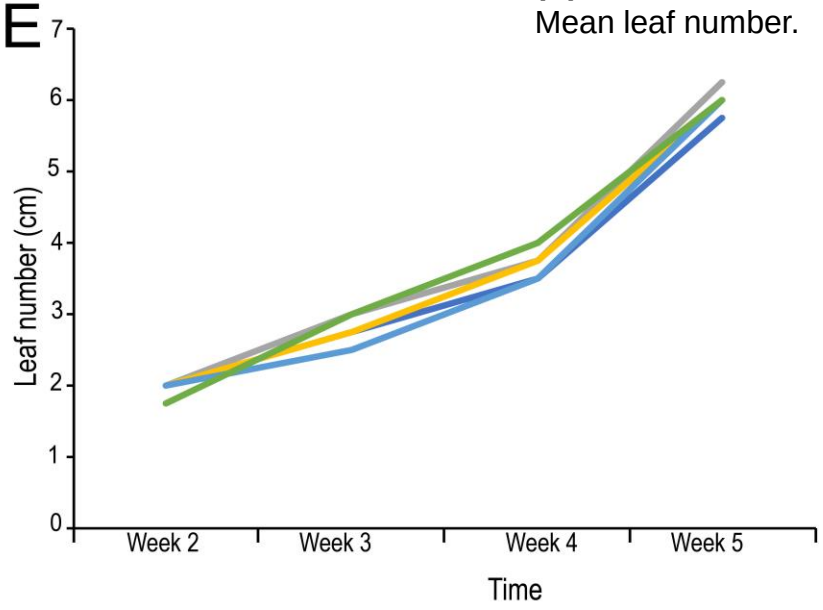




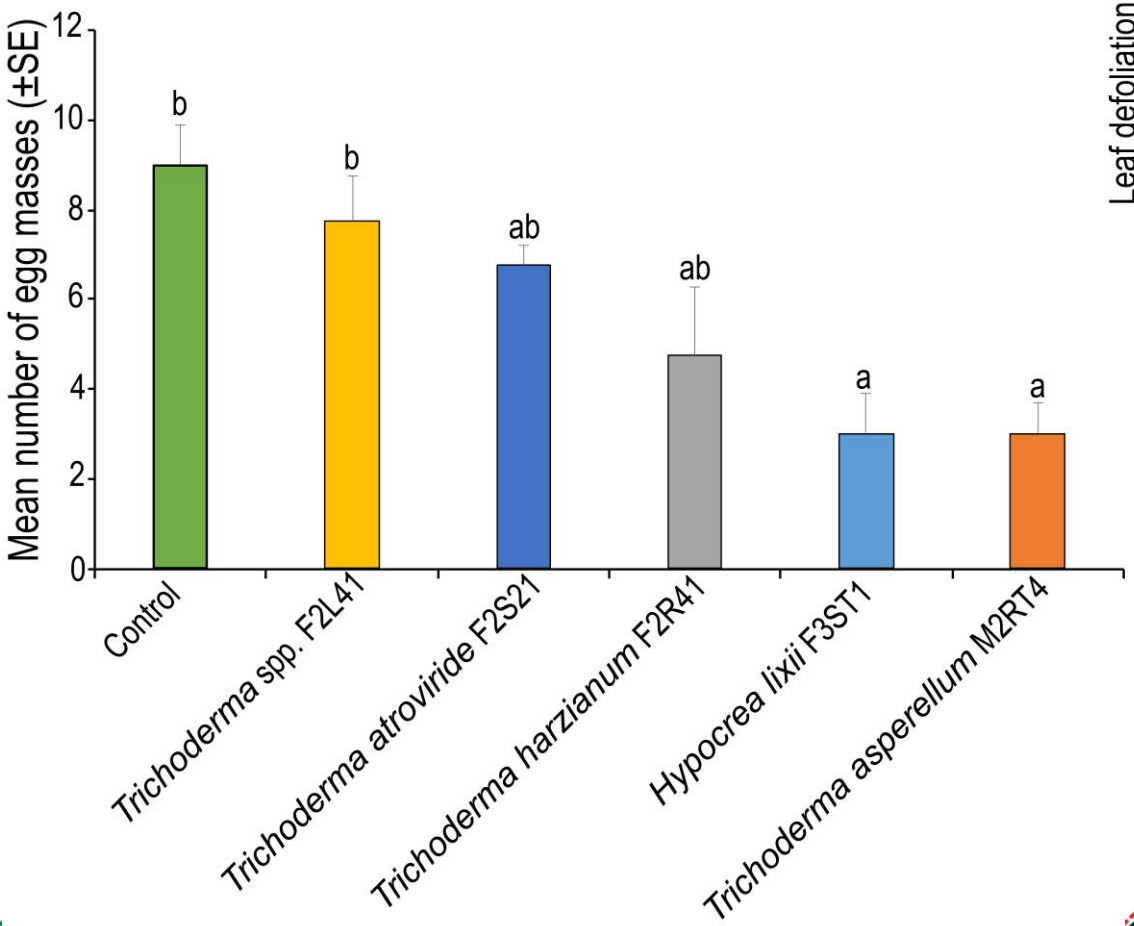
Effect of endophytic colonization on maize seedling growth parameters. **(A)** Mean plant height. **(B)** Mean wet and dry shoot weight. **(C)** Mean leaf length. **(D)** Mean leaf width and **(E)** Mean leaf number.

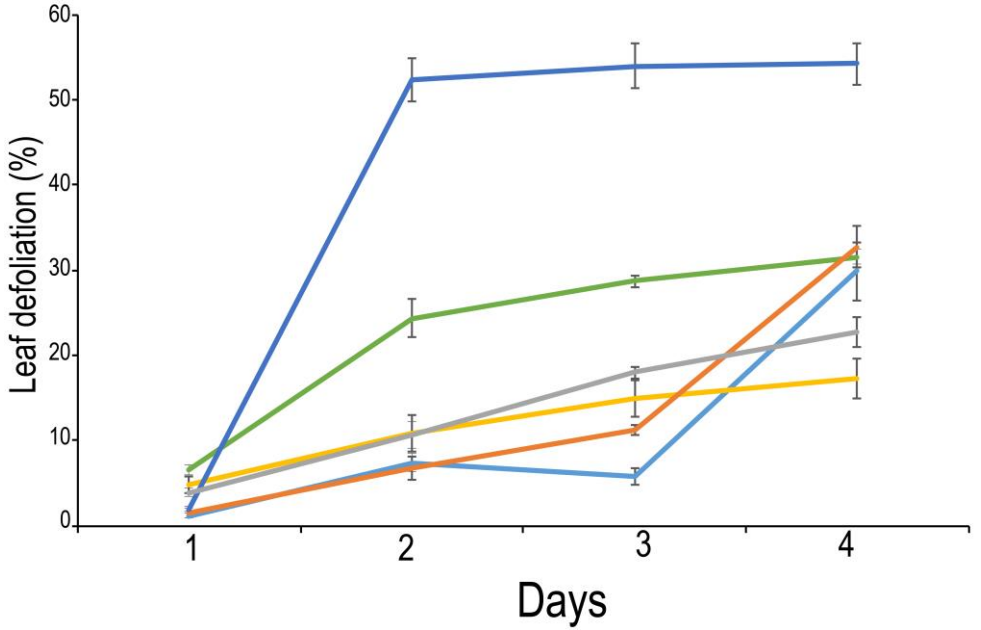




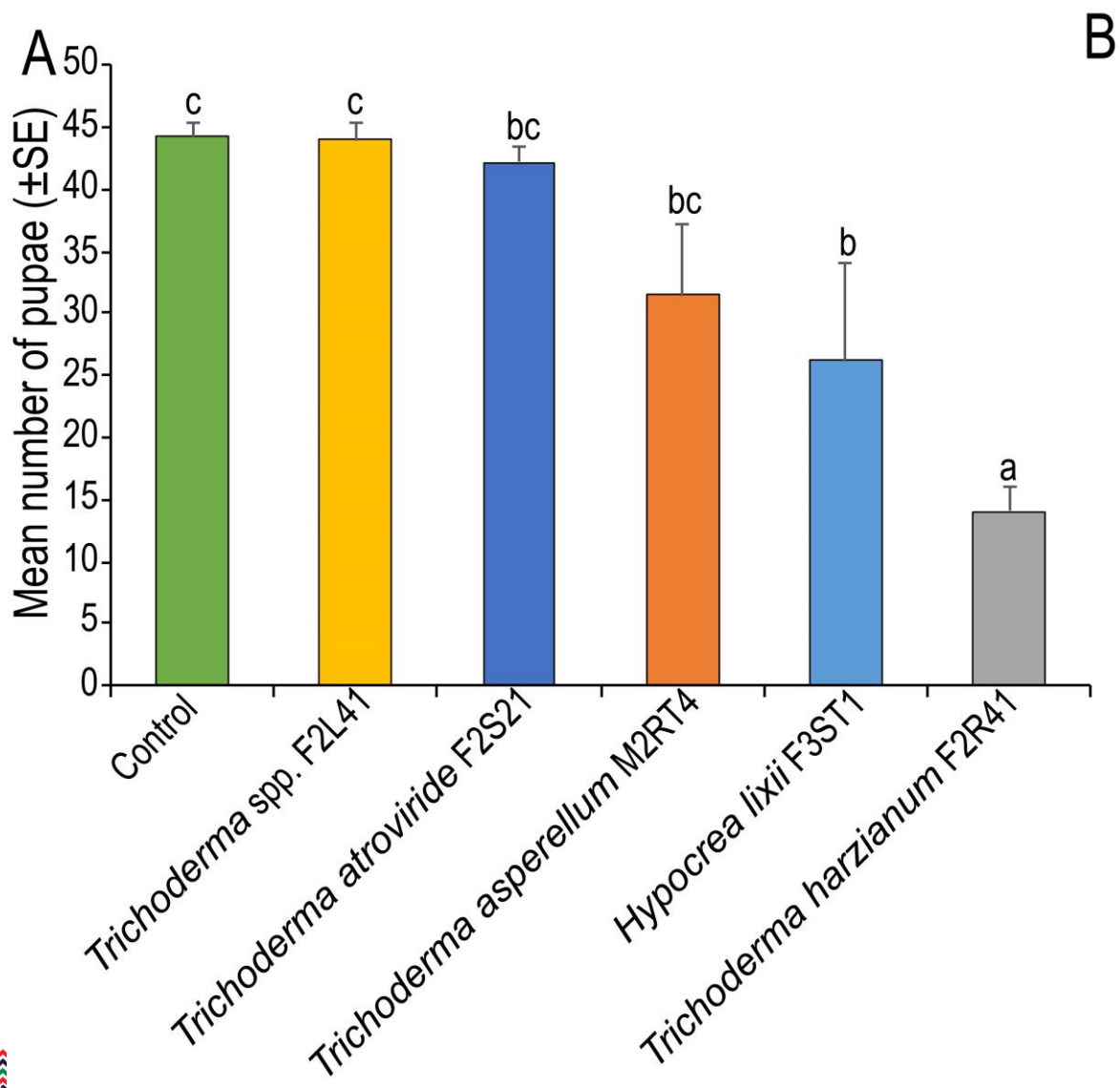


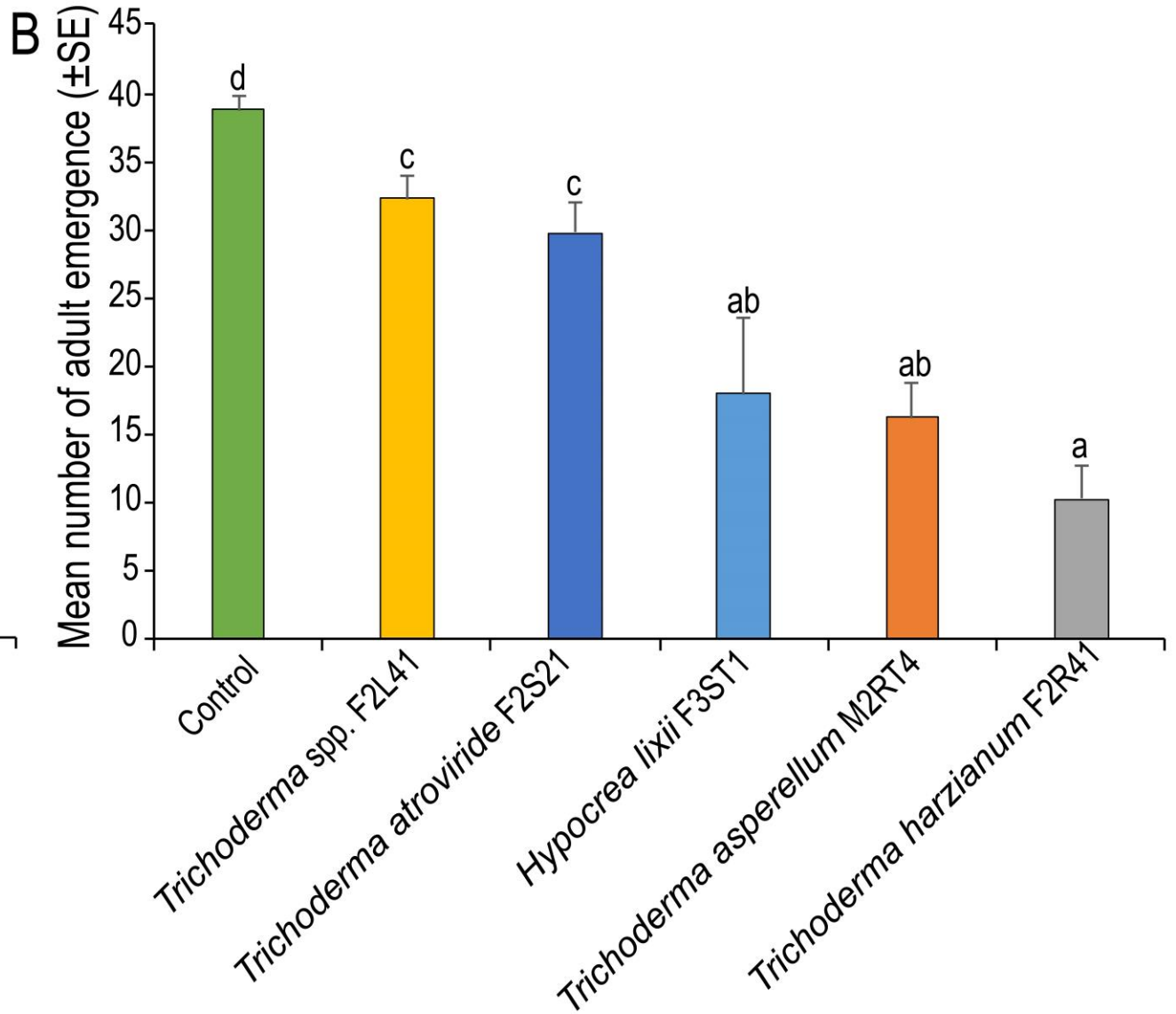
Endophytes effects on reproduction traits and feeding/defoliation



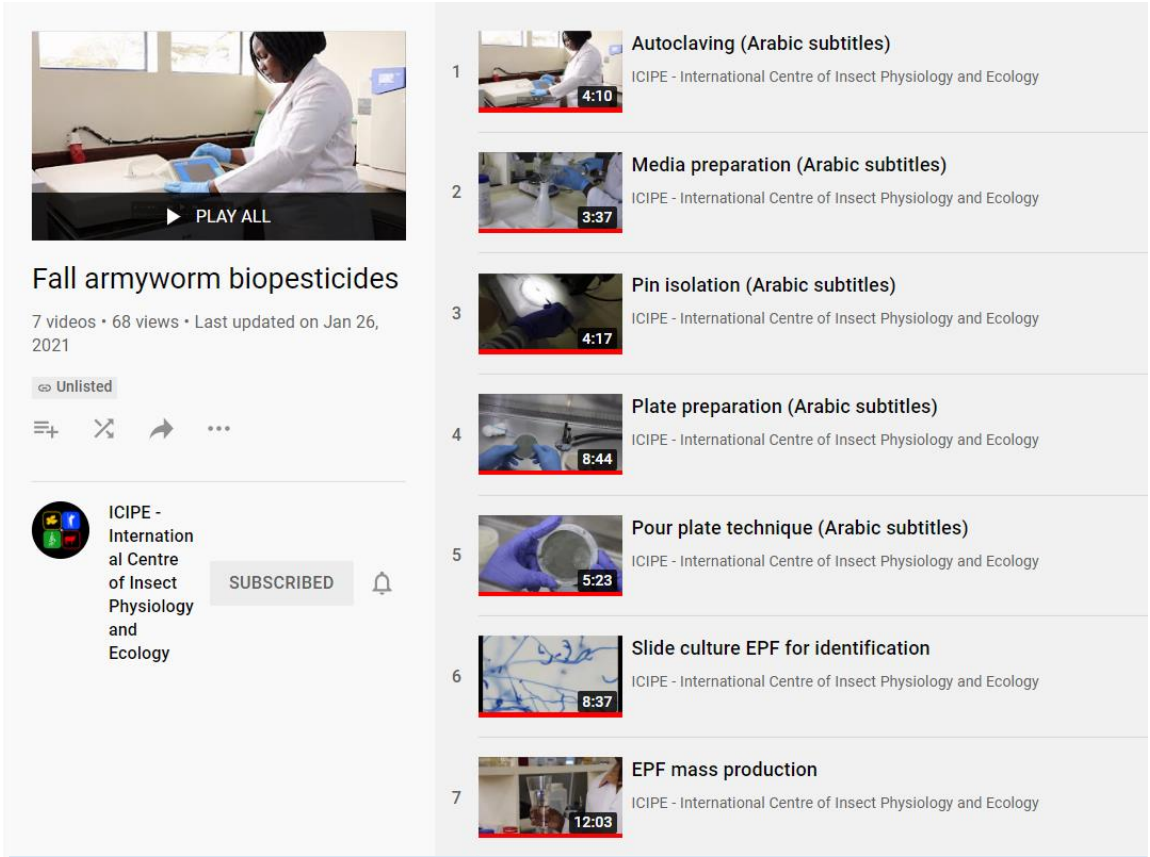


Endophytes effects on pupation and adult emergence





Building capacity of production entomopathogenic fungi



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

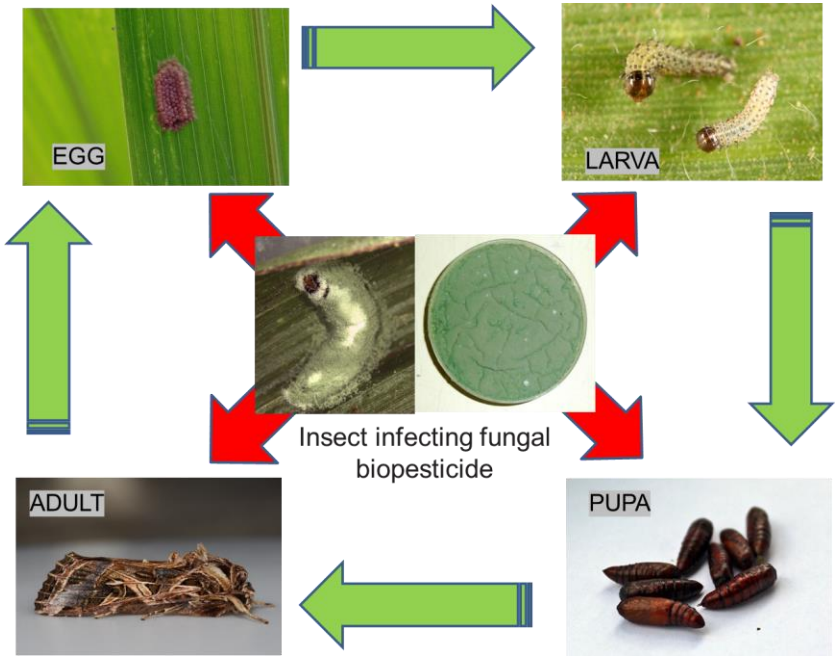
Expanding public-private-partnership for biopesticide scaling

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®

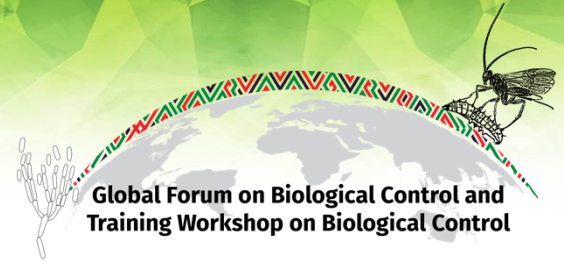


Food and Agriculture Organization of the United Nations

icipe

Donor Acknowledgement

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 Make It Happen

AWARD African Women in Agricultural Research and Development

Australian Government Australian Centre for International Agricultural Research

Austraining International

BAYER

BERTHA FOUNDATION

BILL & MELINDA GATES foundation

BBSRC bioscience for the future

Government of the Republic of Benin

Government of Burkina Faso

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 AGRICULTURAL RESEARCH FOR DEVELOPMENT

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

ECC-SDCOH

Embrapa

ETH zürich

FAO FIAT PANIS

FiBL

FORD FOUNDATION

FNSNF

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Government of Ghana

Google.org

Grand Challenges Canada Grands Défis Canada

IAEA

IDRC CRDI

IFAD Investing in rural people

IFS INTERNATIONAL FOUNDATION FOR SCIENCE

iie

impaxio

IRD Institut de Recherche pour le Développement FRANCE

Innovate UK

IVCC COMBATING INSECT BORNE DISEASE

JRS Biodiversity Foundation

FONDATION L'ORÉAL

Government of South Korea

JIRCAS JAPAN

Keele UNIVERSITY

mastercard foundation

Max Planck Institute for Chemical Ecology

THE McKNIGHT FOUNDATION

MINISTRY FOR FOREIGN AFFAIRS OF FINLAND

moz://a

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

PULSE ASSOCIATION Networking for a greener Africa

R.Geigy-Stiftung

Russell IPM INTEGRATED PEST MANAGEMENT

Norad

The ROCKEFELLER FOUNDATION

THE ROYAL SOCIETY

Government of Rwanda

rss remote sensing SOLUTIONS

Scottish Funding Council Comhairle Maoineachaidh na h-Alba

Government of Senegal

switchafrica GREEN

THE WORLD BANK IBRD • IDA | WORLD BANK GROUP

twas

UNEP

University of Glasgow

USAID FROM THE AMERICAN PEOPLE

USDA

Vetenskapsrådet

VolkswagenStiftung

wellcome

World Health Organization

WORLD TRADE ORGANIZATION

OWSD

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