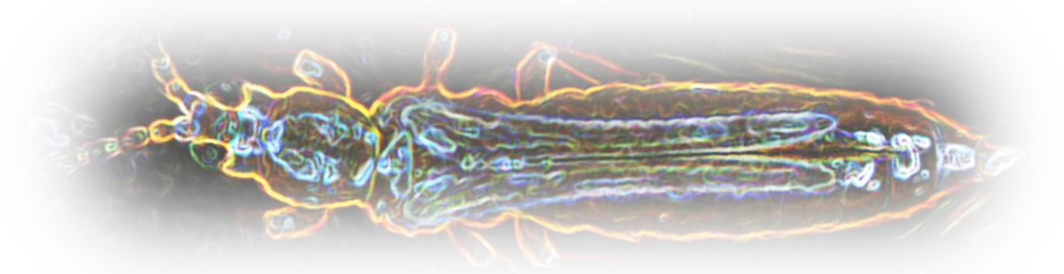
ABIM 2023
23-25 October 2023
Congress Center Basel, Switzerland
www.abim.ch

Successful R&D and Marketing Strategy for *Beauveria bassiana* ERL836 GR and WP for thrips management



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Oct 24, 2023

Global registration of microbial insecticide

Jeonbuk National University ImbL JEF-Platform

Global bioinsecticide: expanding of fungal insecticide market

(Biopesticides of 2014~2022, Agrow 2020 & Local News)

2014	2015	2016	2017	2018	2019
Company & active Ingredient	Company & active Ingredient	Company & active Ingredient	Company & active Ingredient	Company & active Ingredient	Company & active Ingredient
AgBiTech *Helicoverpa zea* NPV (Heligen/US) **Andermatt Biocontrol** *Helicoverpa amigera* NPV (Helicovex/Australia) **Marrone Bio Innovations** *Burkholdeia spp* A396 (Venerate/US) VENERATE BIOINSECTICIDE **Phyllom BioProducts** *Bt galleriae* (GrubGone/US)	**Anatis Bioprotection** *Beauveria bassiana* ANT-03 (Bioceres/US) BioCeres WP **Andermatt Biocontrol** *Autographa californica* NPV (Loopex/Canada) *Cydia pomonella* GV (France) **Andermatt Biocontrol/FMC** *Helicoverpa armigera* NPV (Helicovex/Brazil) **Bayer** Terpenoid blend QRD460 (EU) **Syngenta** *Pasteuria nishizawae* Pn1 (Clariva/Canada) **Valent Biosciecne** *Bt aizawai* ABTS-1587 (Xentari/Canada)	**Andermatt Biocontrol** *Cydia pomonella* GV (Madex/Spain) *Helicoverpa armigera* NPV (Verpavex/Brazil) **AEF Blobal** *Bt kurstaki* EVB-113-19 (US) **AbBiTech** *Spodoptera frugiferda* NPV (Fawligen/US) **Bayer** *Bacillus firmus* I-1582 (Poncho Votivo/New Zealand /Clothianidin) Bayer CropScience PONCHO VOTIVO EPA **Marrone Bio Inniovations** *Chromobacterium subtsugae* PRAA4-1T (Grandevo/Mexico) *Burkholderia rinojensis* A396 (Majestene/Mexico) **Rizoflora Biotecnologia** *Pochonia chlamydosporia* PC10 (Rizotec/Brazil)	**Bayer** *Paecilomyces liacinus* 251 (BioAct Prime/Greece) BioAct PRIME **Arysta LifeScience** *Beauveria bassiana* 147 (EU) *Beauveria bassiana* NPP111B005 (EU) Arysta LifeScience **BASF** BroadBand *Beauveria bassiana* PPRI5339 (Broadband/Autralia) (Velifer/Canada) Velifer Insecticide Biologique **FarmHannong** *Beauveria bassiana* ERL836 (Chongchaesak GR/Korea) 총채싹 BoteGHA ES EMULSIFIABLE SUSPENSION MYCOINSECTICIDE	**AgBiTech** *Chrysodeixis includens* NPV (Surtiva/Agrgentina) **Andermatt BioControl** *Hlicoverpa armigera* NPV BV-0003 (Helicovex/Canada) **BASF** *B. bassiana* PPRI 5339 (Velifer/Canada) BASF Velifer™ **Phyllom Bios** *Bt galleriae* SDS-502 (GrubGONE/Canada) **Syngenta** *Pasteuria nishizawae* Pn1 (Approved/EU) syngenta PASTEURIA bioscience	**BASF** *B. bassiana* PPRI 5339 (Approved/EU) Velifer Insecticide Biologique **Exosect** *B. bassiana* IMI389521 (Approved/EU) exosect Intelligent Pest Management Terramera exosect **Nufarm** cis-jasmone (*B. amyloliquefaciens*) (Trunemco/US) **FarmHannong** *Beauveria bassiana* ERL836 (Chongchaesak WP/Korea)

2021	2022
Company & active Ingredient	Company & active Ingredient
Certis Biologiclas *Beauveria bassiana* GHA 2% ES (Chongchaestop GR, WP /Korea)	**Kyungnong/Global Agro** *Beauveria bassiana* JEF-507 (Chongchaestop GR, WP /Korea)

Entomopathogenic fungi

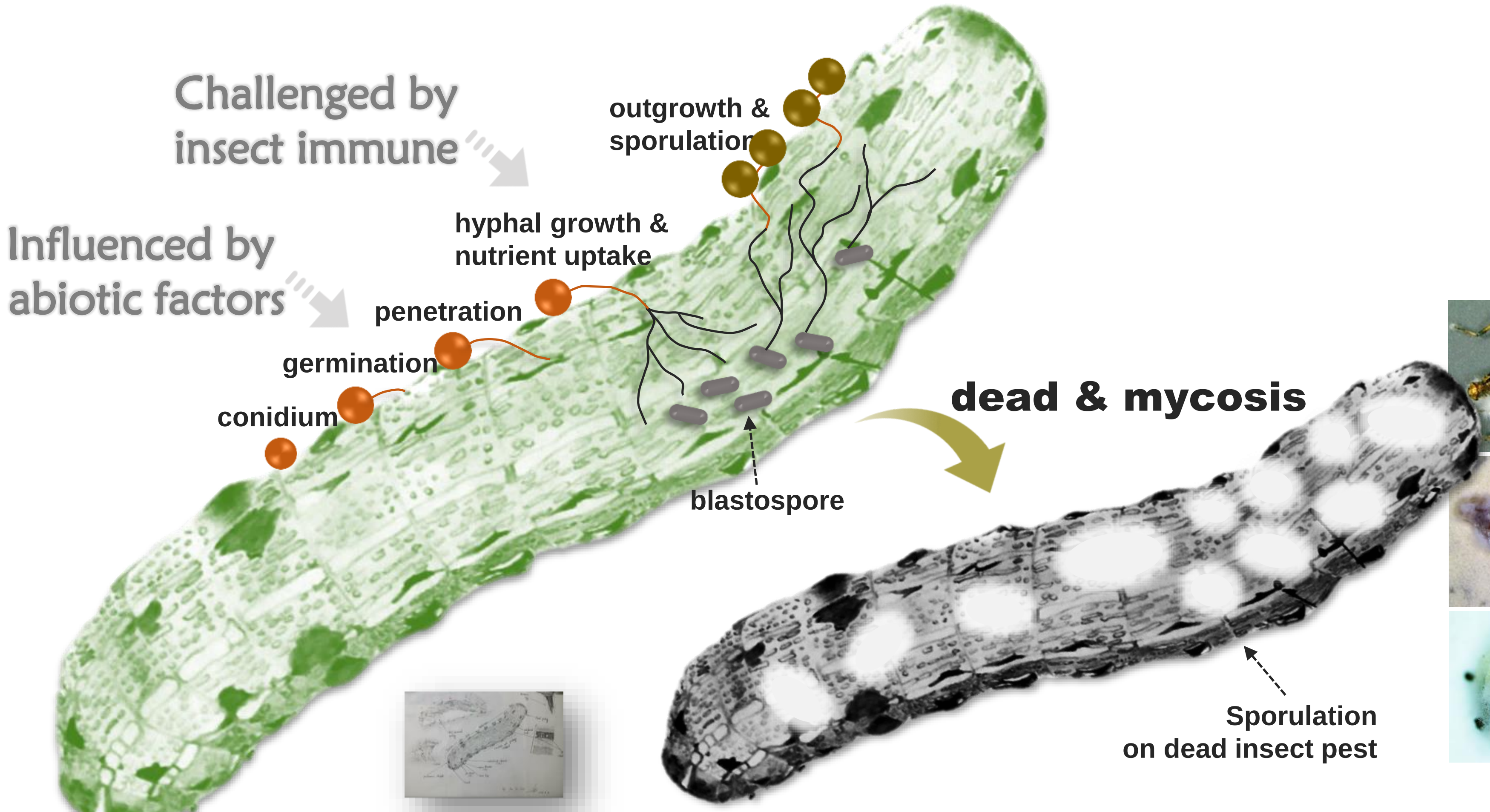
Insect-killing fungi: broad spectrum (but technically short storage and environment-dependent)

IMBL 곤충병원성 진균 데이터베이스
Insect Microbiology & Biotechnology Laboratory

(IMBL, 2019)

Mode of action

Fungal mode of action: hyphal penetration, release of toxic substances and conidial transferring



Sketched by Jae Su KIM (2018)

(IMBL, 2018)

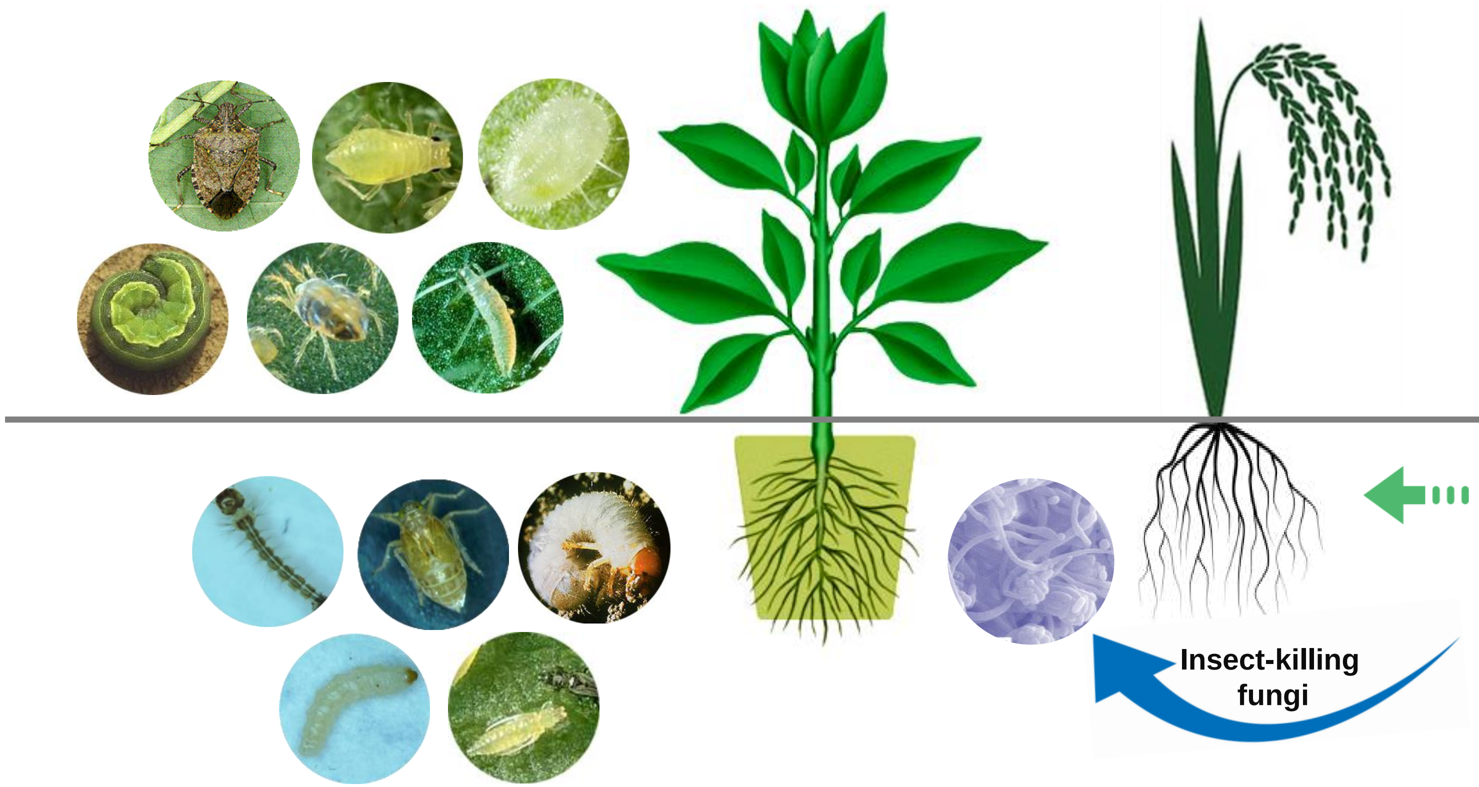
A new approach: ecological biocontrol

Application strategy: where fungi can colonize + reducing residual issue of chemicals

(Lee and Lee et al., Scientific Report, 2018)

Places for microbial application in markets

We need to understand the ecology of target insects.



Soil or water as insect habitat

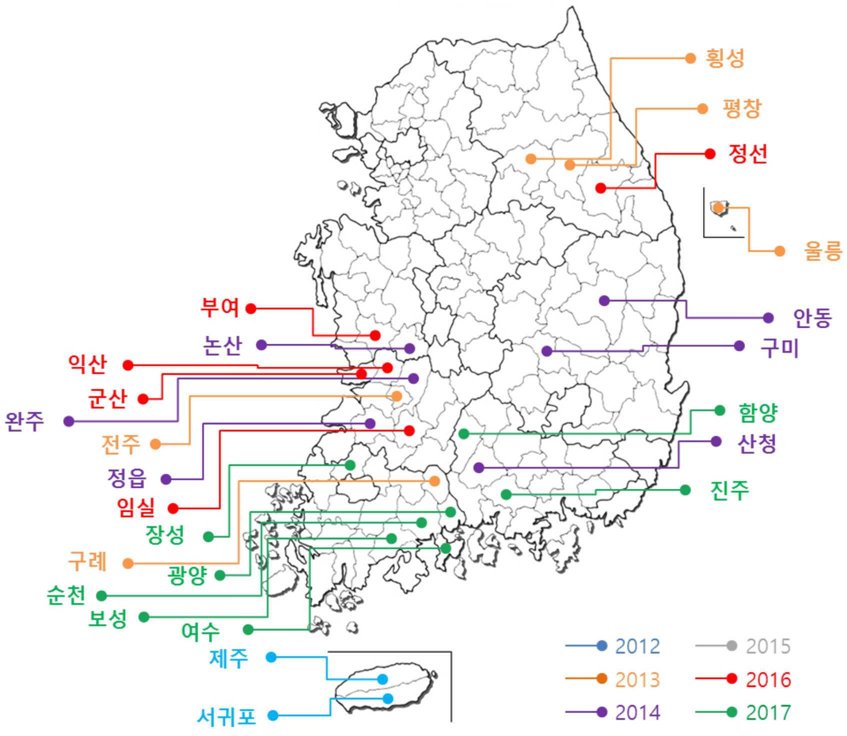
Insect-killing fungi can grow in soil or water very well!

Jeonbuk Nat. Univ. Entomopathogenic Fungi (JEF)

Jeonbuk National University ImbL JEF-Platform

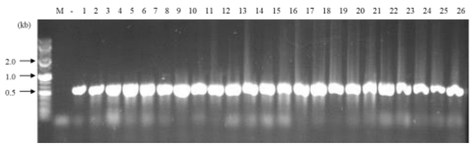
Fungal library: Insect-baiting method (*Tenebrio molitor*) in Korea

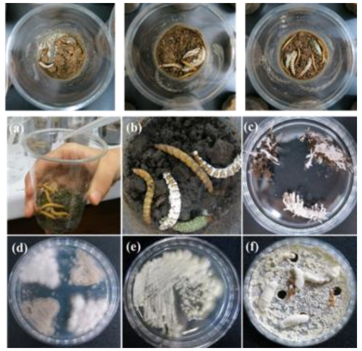
(Kim et al., J Asia-Pacific Entomol. 2018)



(Geographical data for soil sampling)

(ITS sequencing for ID)





(Bioassay against *T. molitor* larvae)

No.	Original Code	Genus	Species	Location	Conidia Color
1	PWS047	*Metarhizium*	*anisopliae*	Jeonju-si, Jeollabuk-do	Green

No.	Original Code	Genus	Species	Location	Conidia Color
26	MMR018	*Isaria*	*fumosorosea*	Iksan-si, Jeollabuk-do	Pink
27	MMR020	*Metarhizium*	*anisopliae*	Iksan-si, Jeollabuk-do	Green

No.	Original Code	Genus	Species	Location	Conidia Color
51	MOS019	*Beauveria*	*bassiana*	Gunsan-si, Jeollabuk-do	White-yellow
52	MOS020	*Metarhizium*	*anisopliae*	Gunsan-si, Jeollabuk-do	Green

No.	Original Code	Genus	Species	Location	Conidia Color
76	RBS011	*Isaria*	*fumosorosea*	Gunsan-si, Jeollabuk-do	Pink
77	RBS012	*Beauveria*	*bassiana*		
78	RBS013	*Codyceps*	*brongniartii*		
79	RBS016	*Metarhizium*	*anisopliae*		
80	RBS017	*Beauveria*	*bassiana*		
81	RBS018	*Codyceps*	*brongiartii*		
82	RBS021	*Beauveria*	*bassiana*		
83	RBS024	*Beauveria*	*bassiana*		
84	RBS025	*Beauveria*	*bassiana*		
85	RBS026	*Beauveria*	*bassiana*		
86	MMD001	*Metarhizium*	*flavoviride*		
87	MMD002	*Metarhizium*	*robertsii*		
88	MMD004	*Metarhizium*	*robertsii*		
89	MMD005	*Isaria*	*fumosorosea*		
90	MMD008	*Clonostachys*	*rosea*		
91	MMD009	*Metarhizium*	*anisopliae*		
92	MMD011	*Metarhizium*	*flavoviride*	Jeongseon-gun, Gangwon-do	Green

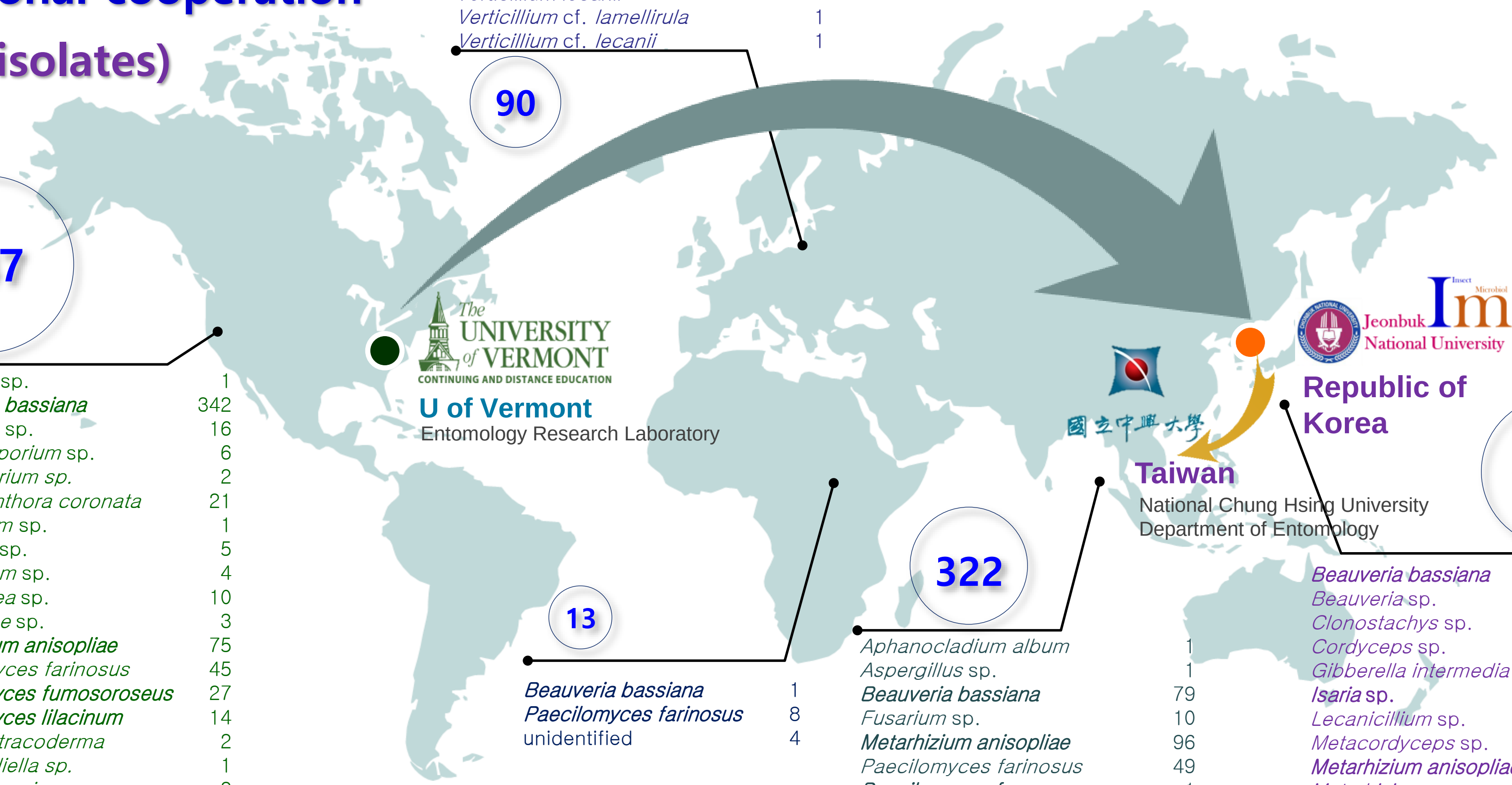
(Entomopathogenic fungal library construction)

Fungal library of JEF at IMBL

Jeonbuk National University ImbL JEF-Platform

A big fungal library construction with international cooperation

(>2,000 isolates)



847

Alternaria sp.	1
Beauveria bassiana	342
Beauveria sp.	16
Cephalosporium sp.	6
Cladosporium sp.	2
Entomophthora coronata	21
Epicoccum sp.	1
Fusarium sp.	5
Geotrichum sp.	4
Mariannaea sp.	10
Marriannae sp.	3
Metarhizium anisopliae	75
Paecilomyces farinosus	45
Paecilomyces fumosoroseus	27
Paecilomyces lilacinum	14
Peziza ostracoderma	2
Rhinocladiella sp.	1
Scopulariopsis sp.	2
Synnematium sp.	1
Trichoderma sp.	32
Verticillium lecanii	60
Verticillium sp.	7
unidentified	170

90

Beauveria bassiana	41
Beauveria sp.	3
Cylindrocarpon sp.	1
Fusarium sp.	5
Paecilomyces farinosus	13
Paecilomyces fumosoroseus	1
Verticillium lecanii	24
Verticillium cf. *lamellirula*	1
Verticillium cf. *lecanii*	1

13

Beauveria bassiana	1
Paecilomyces farinosus	8
unidentified	4

322

Aphanocladium album	1
Aspergillus sp.	1
Beauveria bassiana	79
Fusarium sp.	10
Metarhizium anisopliae	96
Paecilomyces farinosus	49
Paecilomyces fumosoroseus	1
Paecilomyces lilacinum	9
Paecilomyces sp.	6
Scopulariopsis sp.	2
Trichoderma sp.	6
Verticillium lecanii	6
Verticillium psalliottae	4
unidentified	52

1000

Beauveria bassiana	219
Beauveria sp.	6
Clonostachys sp.	3
Cordyceps sp.	9
Gibberella intermedia	1
Isaria sp.	36
Lecanicillium sp.	6
Metacordyceps sp.	5
Metarhizium anisopliae	122
Metarhizium sp.	28
Nomuraea rileyi	3
Paecilomyces sp.	39
Penicillium sp.	4
Pochonia sp.	59
Purpureocillium sp.	18

Western flower thrips (*F. occidentalis*)

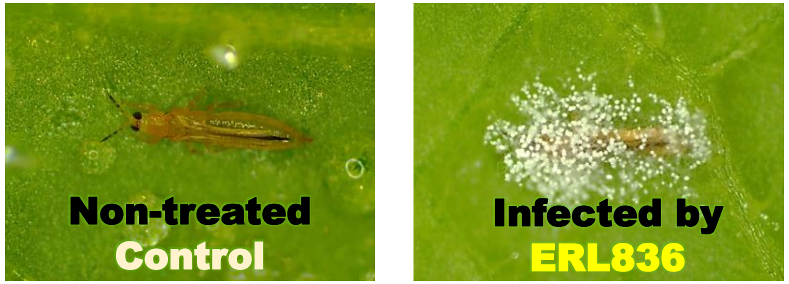
Resistance of thrips: alternative with different mode of action and environmentally sound

IMBL, Jeonbuk National University

Pathogenesis of *B. bassiana* ERL836 against thrips

Insecticidal activity of ERL836: high activity against western flower thrips

Bioassay against thrips

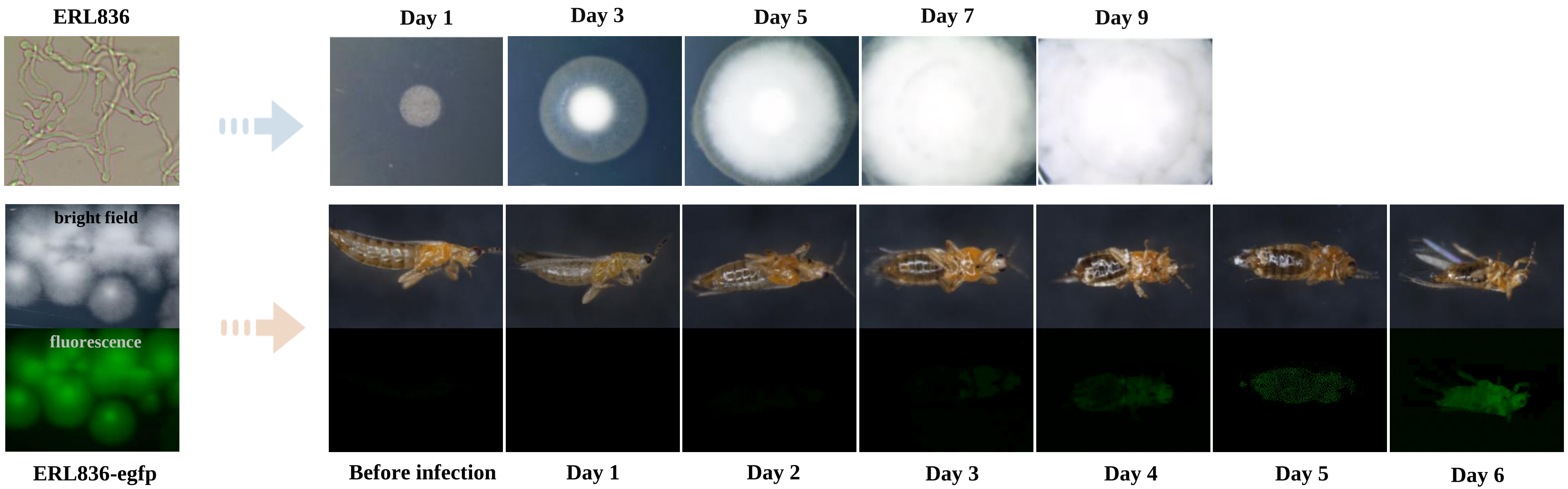


National Library of Medicine — National Center for Biotechnology Information — *B. bassiana* ERL836 (GenBank GCA_010099065)

(Kim et al., SIP Gold Medal Award Video. 2018)

Growth

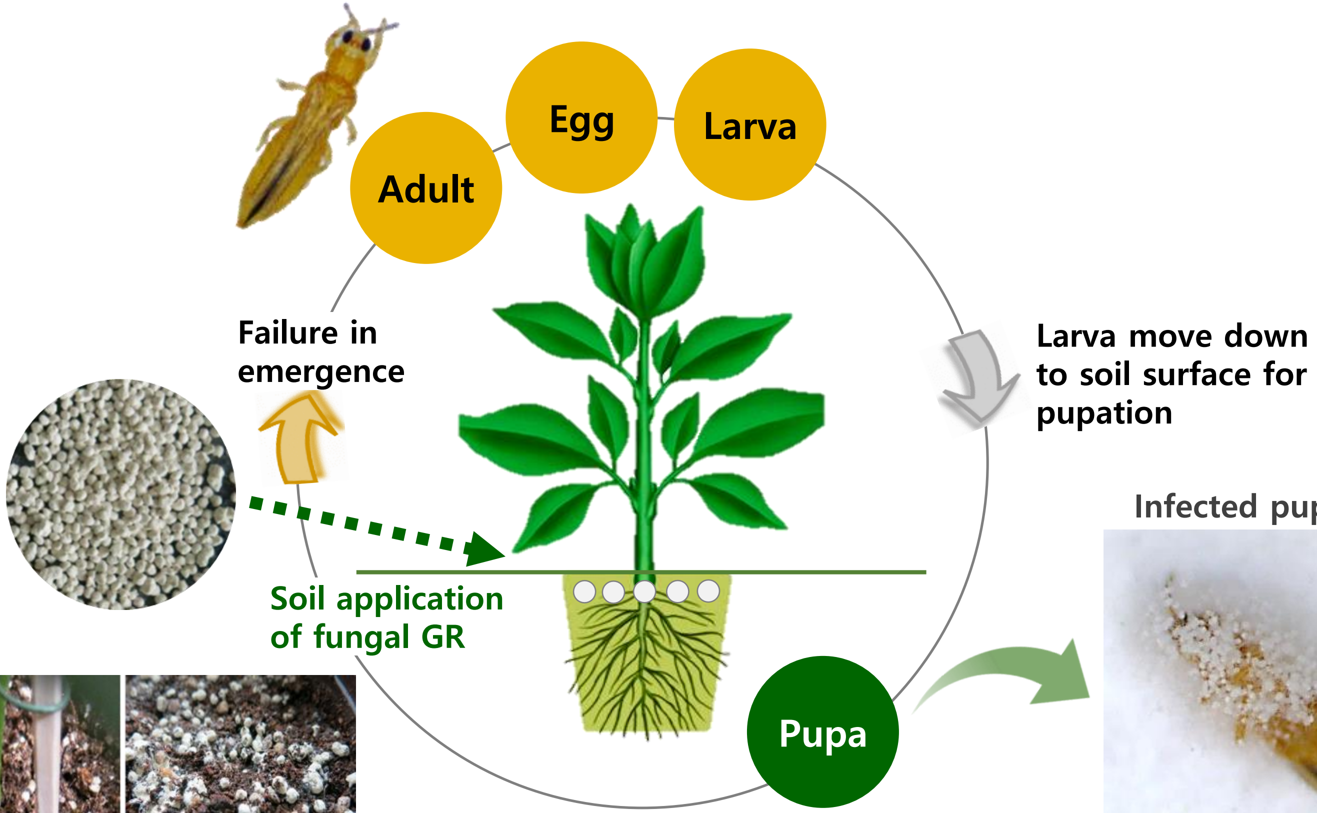
Infection



Concept of *B. bassiana* ERL836 for thrips management

New concept of application: targeting soil-dwelling stage of thrips

(Lee et al., 2017. BioControl; Skinner et al., 2012. Biological Control)



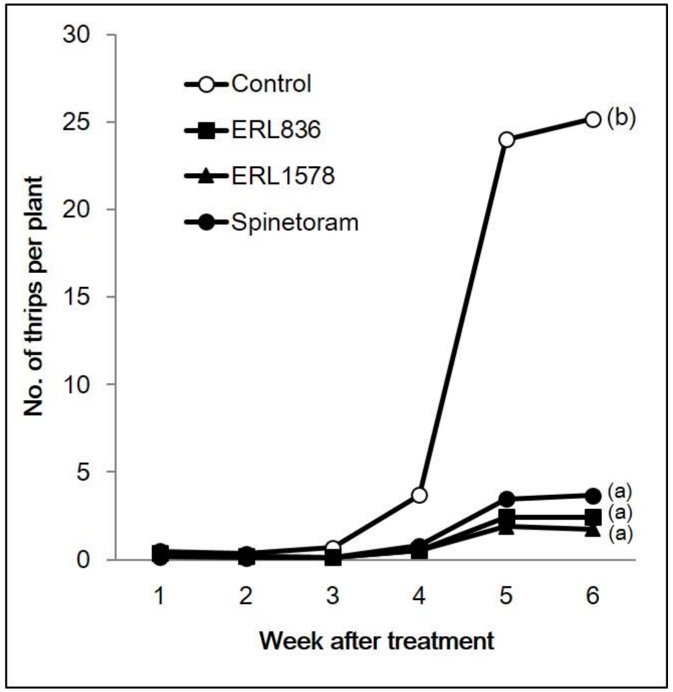
Infected pupae by ERL836

Field data of *B. bassiana* ERL836 GR against thrips

Field test : High performance in cucumber and rose (applied to many other crops)

0 day

7 days



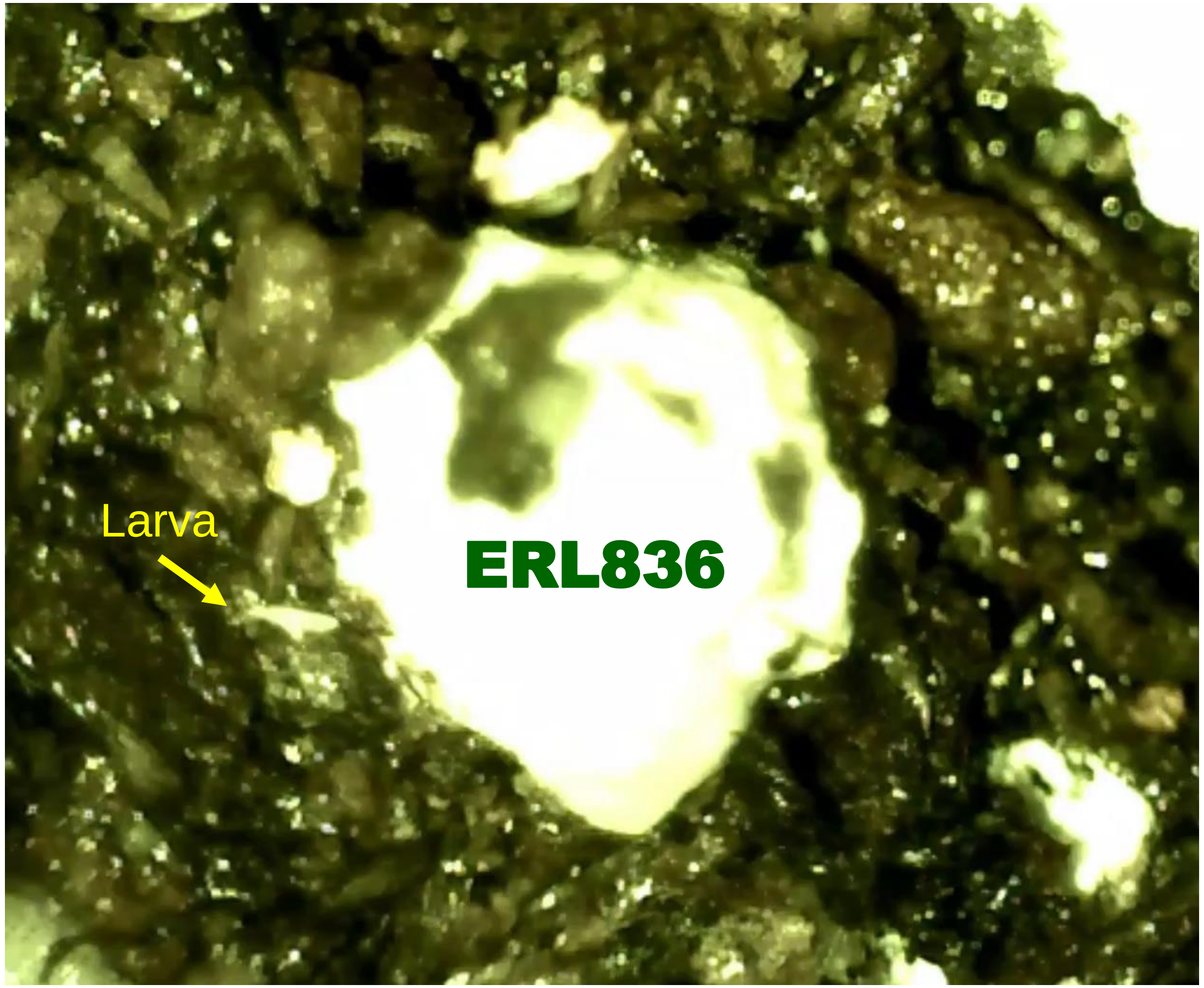
Trt No.	Treatment Name	Form Conc	Form Unit	Form Type	Rate	Rate Unit	Application method	Control efficacy (%)
1	Control	-	-	-	-	-	-	[% live thrips = 839.5]
2	*Bb* ERL836	10^7	conidia/g	GR	3	kg/10a	Soil application	91.3
4	*Bb* ERL1578	10^7	conidia/g	GR	3	kg/10a	Soil application	93.0
6	Spinetoram (Chemical)	5	%	WG	0.5	g/L	Foliar application	85.5

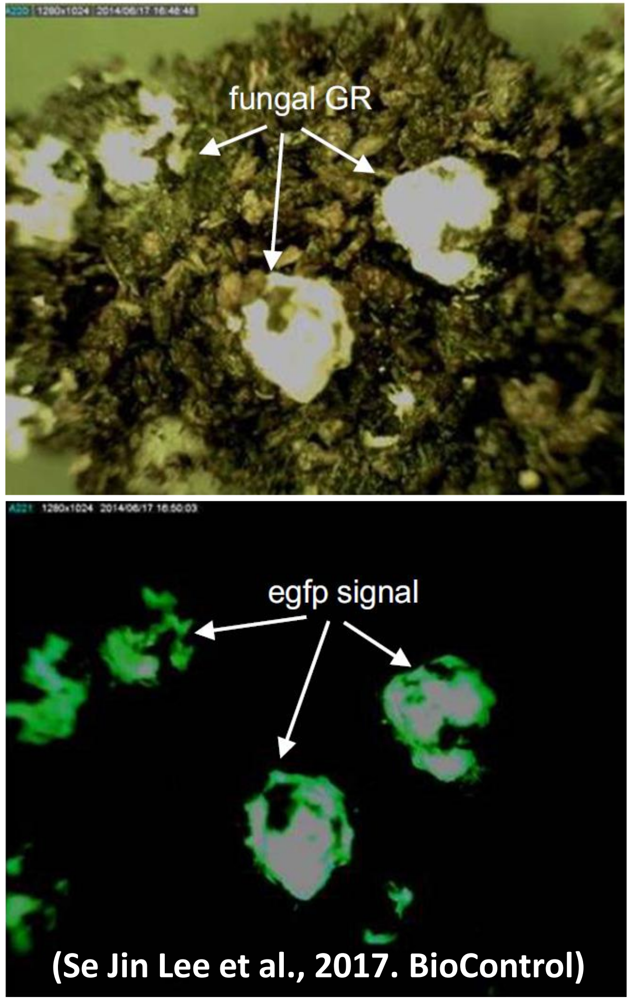
No	Treatment	Form Conc.	Form Unit	Form Type	Form Rate	Rate Unit	Efficacy(%) 28 DAT	Efficacy(%) 42 DAT
1	Check	-	-	-	-	-	-	-
2	ERL 836	2.5	%	GR	3	kg/10a	60.0	69.2
3	ERL 1578	2.5	%	GR	3	kg/10a	54.3	61.5
4	Clothianidin	1.8	%	GR	3	kg/10a	77.1	76.9

(Lee et al. 2017. BioControl)

Contact of ERL836 to thrips in soil

Application of ERL836: Soil application to control larvae and pupa





(Se Jin Lee et al., 2017. BioControl)

Video by Jae Su Kim, IMBL, Jeonbuk National University

Field application of ERL836 GR in cucumber

Jeonbuk National University ImbL JEF-Platform

GR application in farmer's field: Soil application after transplanting (to overcome resistance)

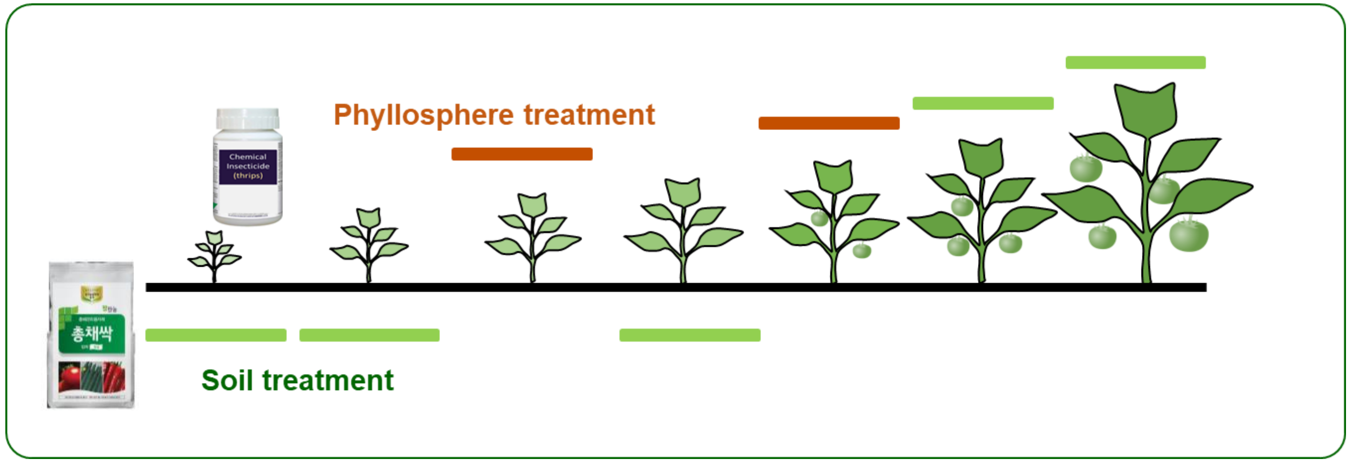
Interviewed by
Mi Rong Lee

Combinational application with chemicals

Combination with chemicals: Synergistic effect on both of chemicals and ERL836

- ✓ **Chemicals could be more easily penetrated to insect body** by the holes which were made by fungal hyphal penetration.
- ✓ **Insect-killing fungi could more easily penetrate hard and strong insect cuticles** because of the softened cuticles which was contributed by chemicals.
- ✓ Tank-mix or serial application of chemicals and biologicals could be very synergistic approach and reduce the amount of chemicals and overcome the residual issues in crop harvest.

(Lee et al., 2017. BioControl)



Storage stability of *B. bassiana* ERL836 (4 years)

Storage stability: At room temperature for four years

(Kim et al., 2019, J Asia-Pacific Entomol)

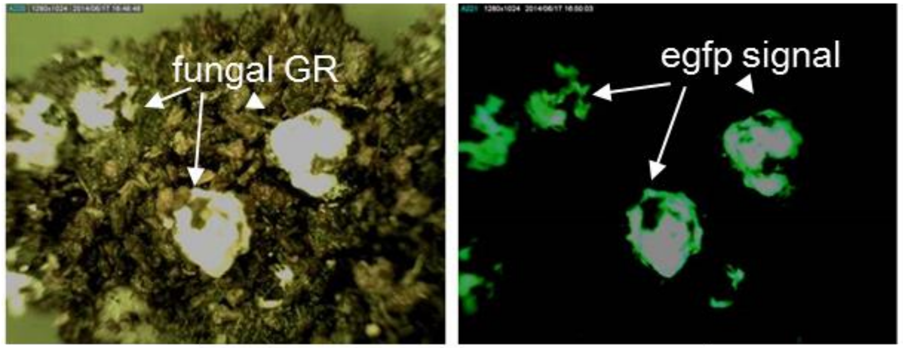
Active ingredient	Trade name	Country of the company	Formulation	Storage condition	Shelf life (months)	Reference website
Beauveria bassiana						
	Bassianil	Columbia	WP, 1x10^9 CFU / g	≤ 24 °C	6	http://www.controlbiologico.com/
	Bassianil	Columbia	WP, 1×10^9 CFU / g	4-10 °C	3	
	Bb Plus	South Africa	WP, 2×10^{10} CFU / g	4 °C	9	https://www.biocontrol.co.za/
	BbWeevil	South Africa	Dusting powder, 2×10^{10} CFU / g	4 °C	9	https://www.biocontrol.co.za/
	Bea-Sin	Mexico	WP, 5×10^9 CFU / g			
	Bibisav-2	Cuba	Bait composition, 1×10^9 conidia / g	10-20 °C	3	
	Bio-Power	India	Liquid, 1×10^9 CFU / ml WP, 1×10^8 CFU / g	N/A	12	http://www.tstanes.com/
	BotaniGard® 22WP	USA	WP, 4.4 ×10^{10} spores / g	20-25 °C	12	https://www.bioworksinc.com/
	BotaniGard® ES	USA	ES, 2 ×10^{13} spores / ml	20-25 °C	18	https://www.bioworksinc.com/
	BotaniGard® MAXX	USA	Emulsifiable dispersible oil, 1 ×10^8 spores / ml	20-25 °C	12	https://www.bioworksinc.com/
	ChongchaeSak ERL836	Republic of Korea	Granules, > 1 × 10^5 CFU / g	< 30 °C	24	http://www.farmhannong.com/
	Multiplex Baba	India	Liquid and powder, N/A	N/A	N/A	http://www.multiplexgroup.com/
	Mycotrol® ESO	USA	Liquid emulsifiablesuspension, 2 ×10^{10} spores / ml	20-25 °C	18	https://www.bioworksinc.com/
	Mycotrol® WPO	USA	WP, 4.4 ×10^{10} spores / g	20-25 °C	12	https://www.bioworksinc.com/
	Naturalis-L®	USA	Oil dispersion formulation, 2×10^7 CFU / ml	4-5 °C	12	http://belchim.co.uk/ http://www.troybiosciences.com/
	Probiobass	Bolivia	N/A	N/A	N/A	http://www.probiotec.org/
	Racer™	India	Powder, 1×10^8 conidia / g	N/A	12	http://www.agrilife.in/
	Teraboveria	Guatemala	WP, N/A	20-25 °C	3	http://www.agricolaelsol.com/
Beauveria brongniartii						
	Beavaria brong	Italy	Barley kernels, 7.5 ×10^9 conidia / g	2 °C	12	http://agrobionsa.anclastudio.com/
	Betel	France	Clay microgranules	N/A	N/A	
	Melocont® Pilzgerste	Austria	Barley kernels, 7.5 ×10^9 conidia / g	2 °C	12	https://www.samen-schwarzenberger.at/home.html
Cordyceps fumosorosea (formerly *P. fumosoroseus*)						
	PreFeRal WG	Belgium	Water-dispersible granule, 2 ×10^9 CFU / g	2-6 °C	6	https://www.biobestgroup.com/
Lecanicillium spp.						
	Mealikil® VL	India	WP, 1×10^8 CFU / g		12	http://www.agrilife.in/
	Vertalec	The Netherlands	WP, 1×10^9 blastospore / g	2-6 °C	6	
	Mycotal	The Netherlands	WP, 1×10^{10} CFU / g	2-6 °C	6	https://www.koppert.com/
Metarhizium anisopliae						
	BioCane™	Austria	Rice granules, 2×10^9 conidia / g	5-10 °C	6	
	Met-92	Guatemala	WP, N/A	20-25 °C	3	
	Pacer®	India	WP, 1×10^8 CFU / g		12	http://www.agrilife.in/

Commercial *B. bassiana* ERL836 GR & WP

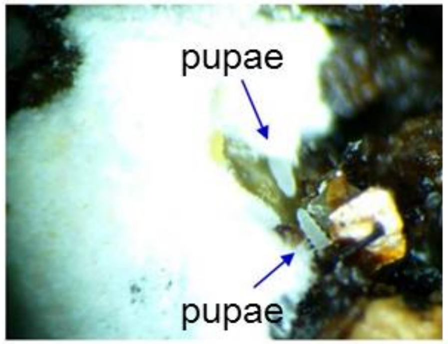
ERL836: GR-soil application at 3 kg/1,000 m^2 & WP-drenching 400 g/1,000 m^2

- **Active ingredient** : *Beauveria bassiana* ERL 836 5% GR and 2.5% WP
- **Target Pest** : Thrips
- **Mode of Action :** Targeting pupal stage & hyphal attack and immune suppression
- **New concept of soil treatment product for controlling thrips**
  - After the soil treatment, control efficacy lasts >40 days by one time of application.
  - For effective control of thrips, pupae in soil should be contacted to the fungus.

Target Pest	Application time	Dose
Thrips Whitefly	**GR: Soil application before transplanting** **WP: Soil drenching & Foliar spray**	**GR: 3 kg /1000 m^2** **WP: Drenching 400 g/1000 m^2, Spray 1,000X**



Bb-egfp granules in soil



Contact of thrips pupae to colonized *Bb*-egfp fungal mass in soil

Research publications for ERL836

Academic publications: virulence, production, stability, genome, RNA-seq & mode of action

Margaret et al., 2012. **Biological Control**
Lee et al., 2017. **BioControl**
Lee et al., 2018. **Scientific Report**
Kim et al., 2019. **J Asia-Pacific Entomol**
Kim et al., 2020. **BMC Genomics**
Gasmi et al., 2021. **Scientific Report**
Kim et al., 2022. **PLOS ONE**

Industrialization in Korea

Successful launching in Korean local market, 2017 and now MS No. 1 in Korea

Farmers' favorable review

Release ERL836 WP 2020

Launching GR (2017, Korea)
WP (2020, Korea)

Award of National Medal (2018)

→ Jae Su Kim's lab (Jeonbuk National University)

Jeonbuk National University, University of Vermont, and FarmHannong

Student training at Jeonbuk National University

→ Test in Japan showed excellent performance (2023, Japan)
(under discussion of registration in Japan)

Jeonbuk National University ImbL JEF-Platform

Acknowledgements to my students