Reining in microbes:

Can microbial biocontrol catch up with entomological biocontrol?

Andrew C Wylie PhD

“Strangers in the land of soil microorganisms have little chance for survival: conditions and competition are so harsh that soil is not a reservoir for pathogens, but it is a true burial ground for disease – delicate parasites cannot survive in the company of soil microbes”

-H.S. Goldberg & T.D. Luckey, 1959

Outline

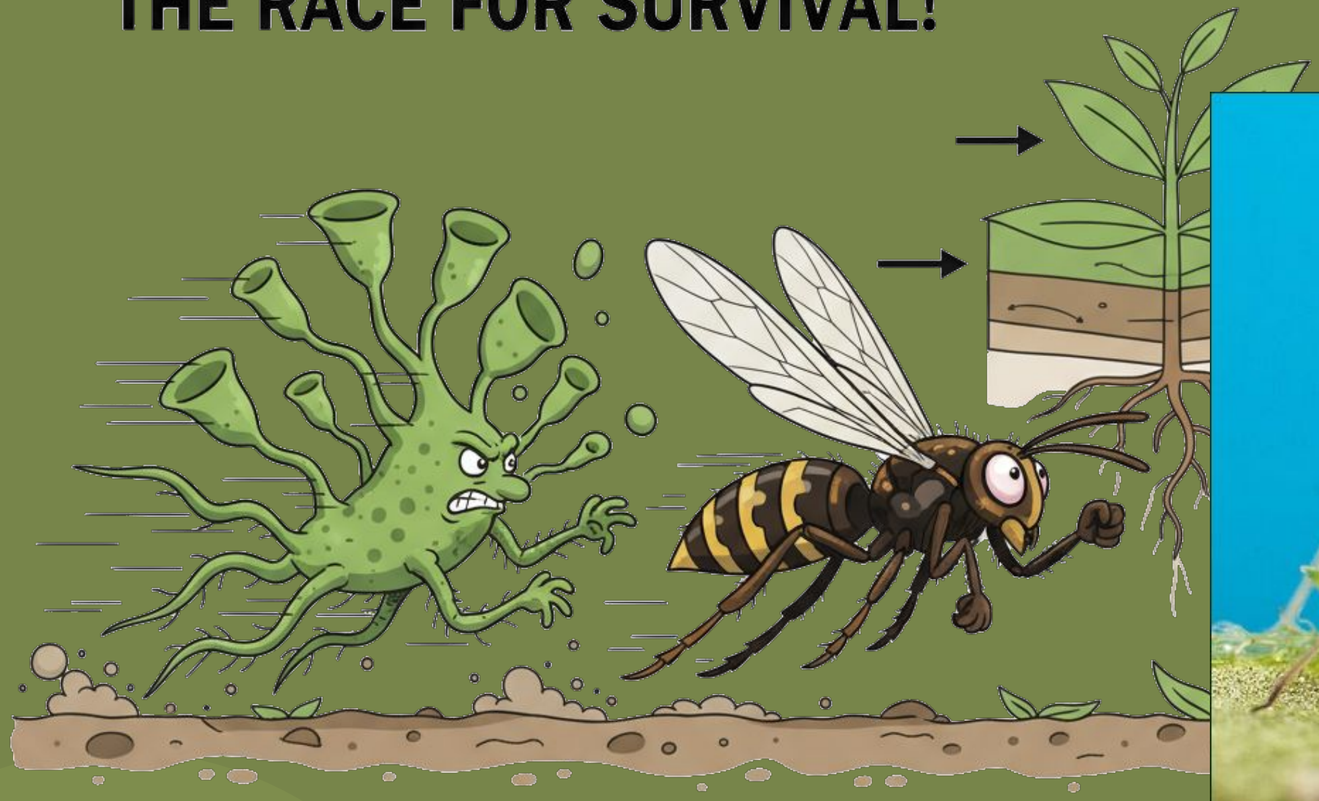
Arthropod and Microbial Biocontrol

Barriers to Adoption

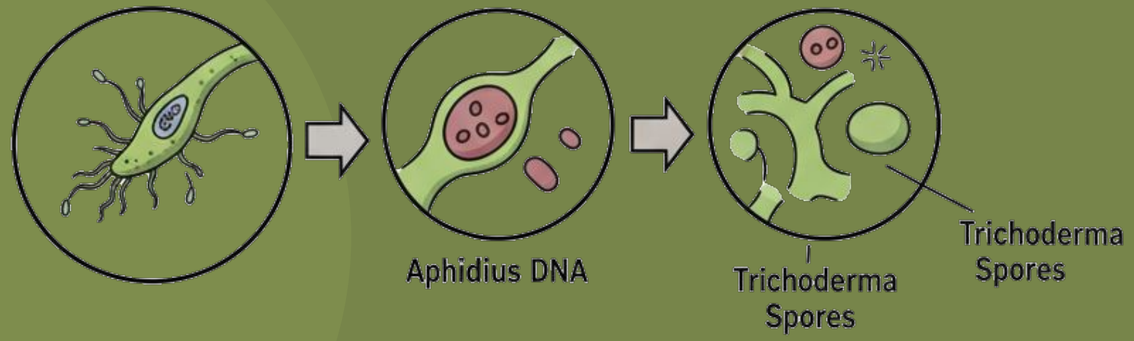
New Tools

Practical Implementation

BIOLOGICAL VELOCITY: THE RACE FOR SURVIVAL!

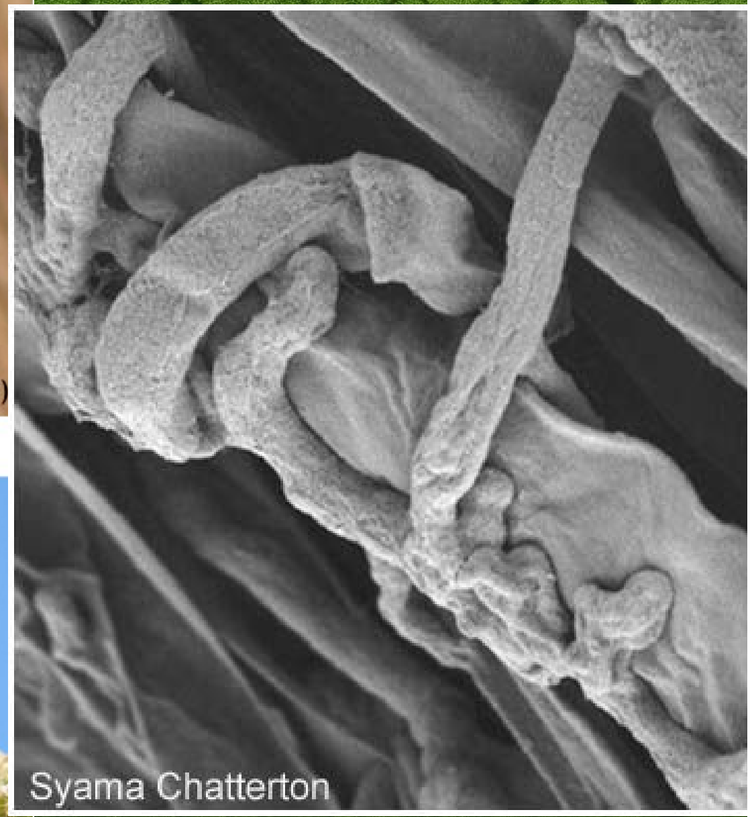


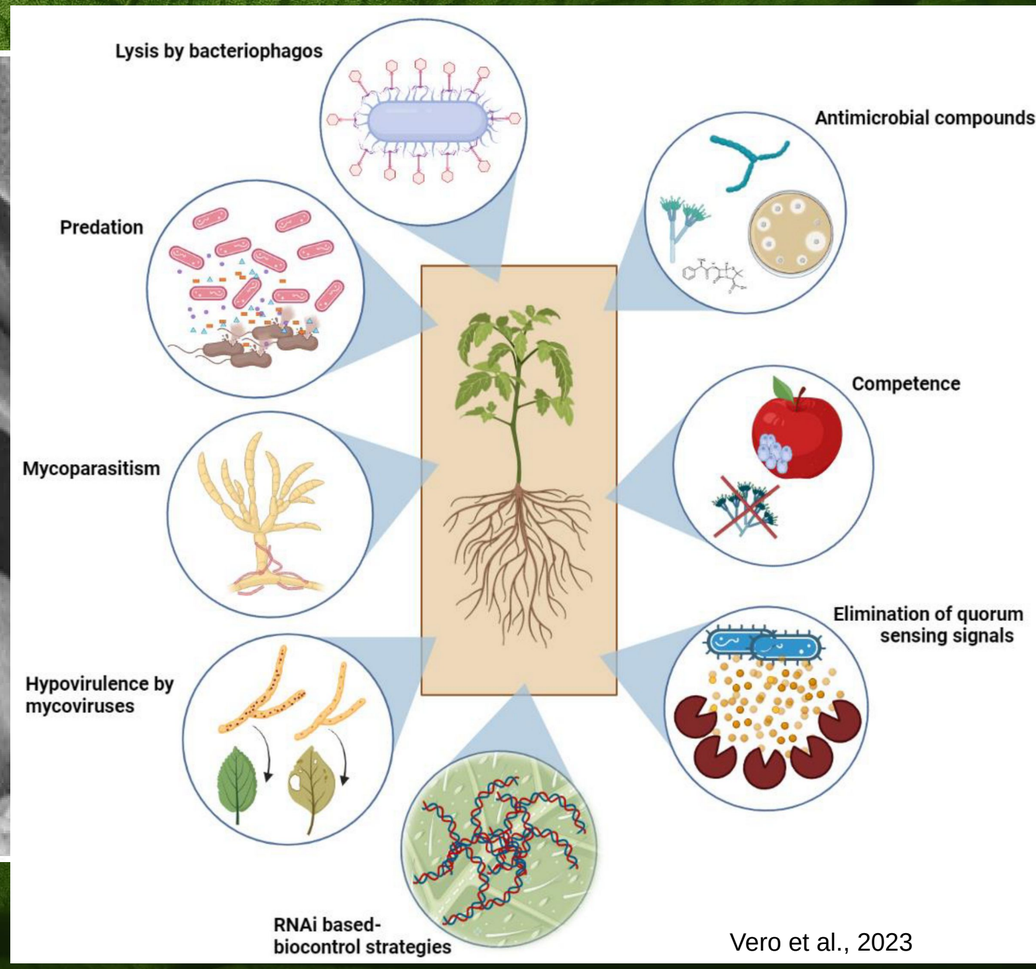
Wasp leads, but Fungus Accelerate!



Why is Entomological Biocontrol Ahead?

- Practical
- Regulatory
- Success in insect systems
- Ease of demonstration
- Clear trophic interactions
- Robust market structure



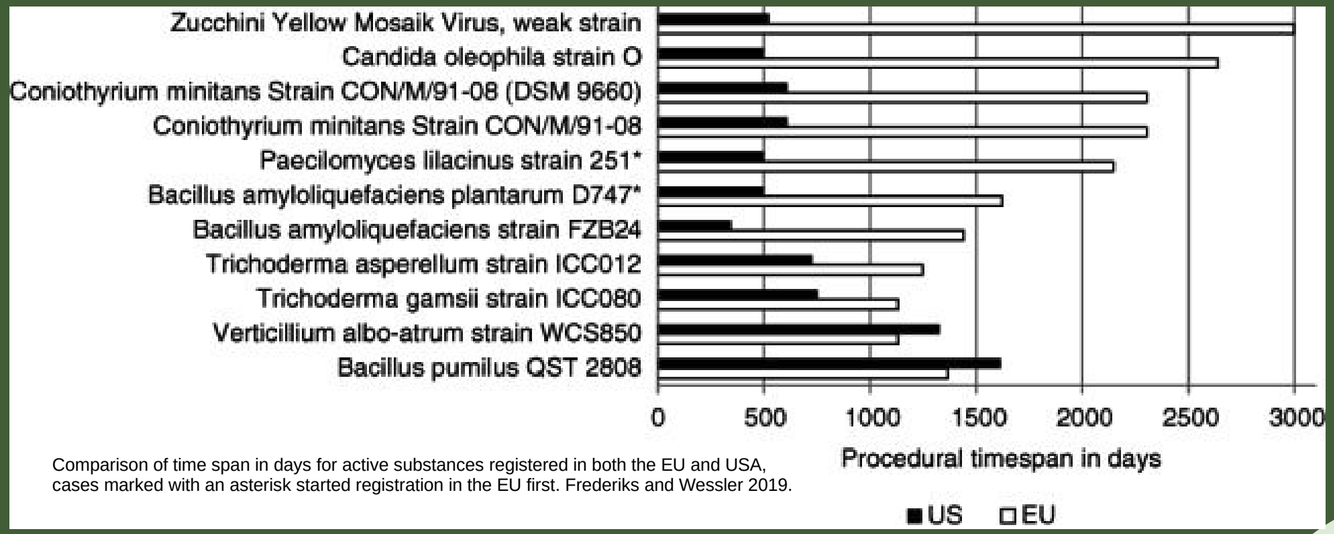


Vero et al., 2023

Barriers to Microbial Biocontrol Adoption

- Inconsistent Efficacy
  - Ecological complexity
  - Environmental variables
  - Host-pathogen interactions

- Research and Regulatory
  - Screening
  - Commercial deployment

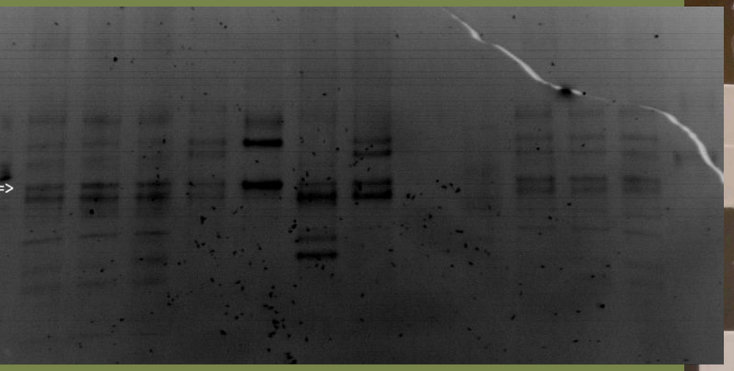


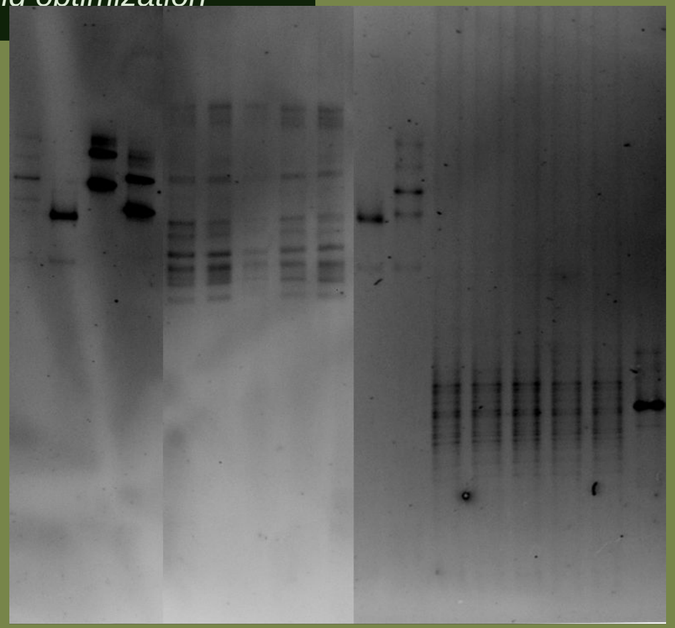
Comparison of time span in days for active substances registered in both the EU and USA, cases marked with an asterisk started registration in the EU first. Frederiks and Wessler 2019.

New Tools for Microbial Biocontrol

Metagenomics + Metabolomics
Deeply characterize disease and biocontrol ecology

Molecular Selection
Specificity, reliability, efficacy
Bioprospecting, consortia and optimization





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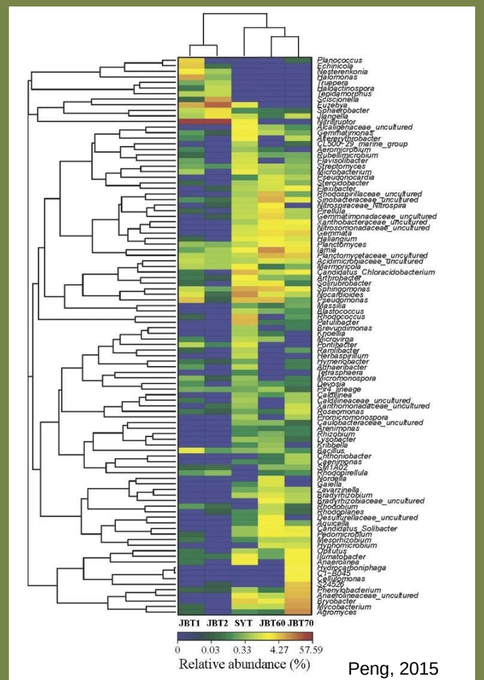
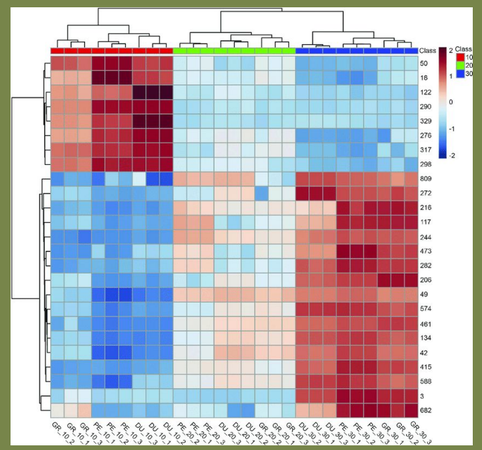
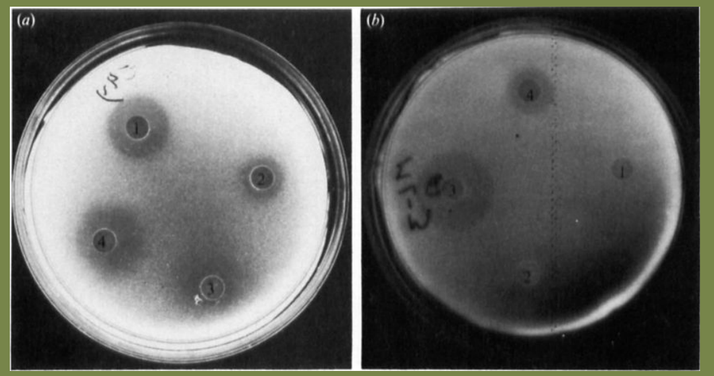


Peng, 2015

+

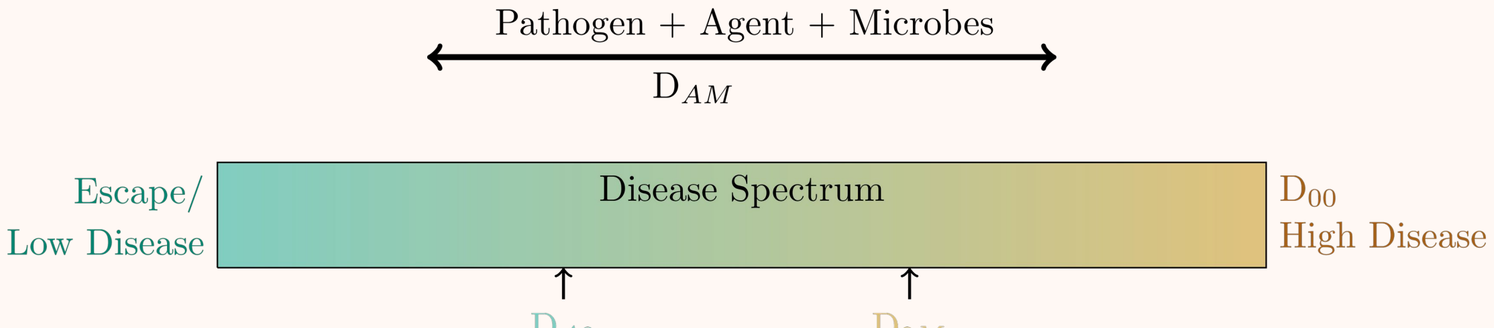


Mokochinski 2017

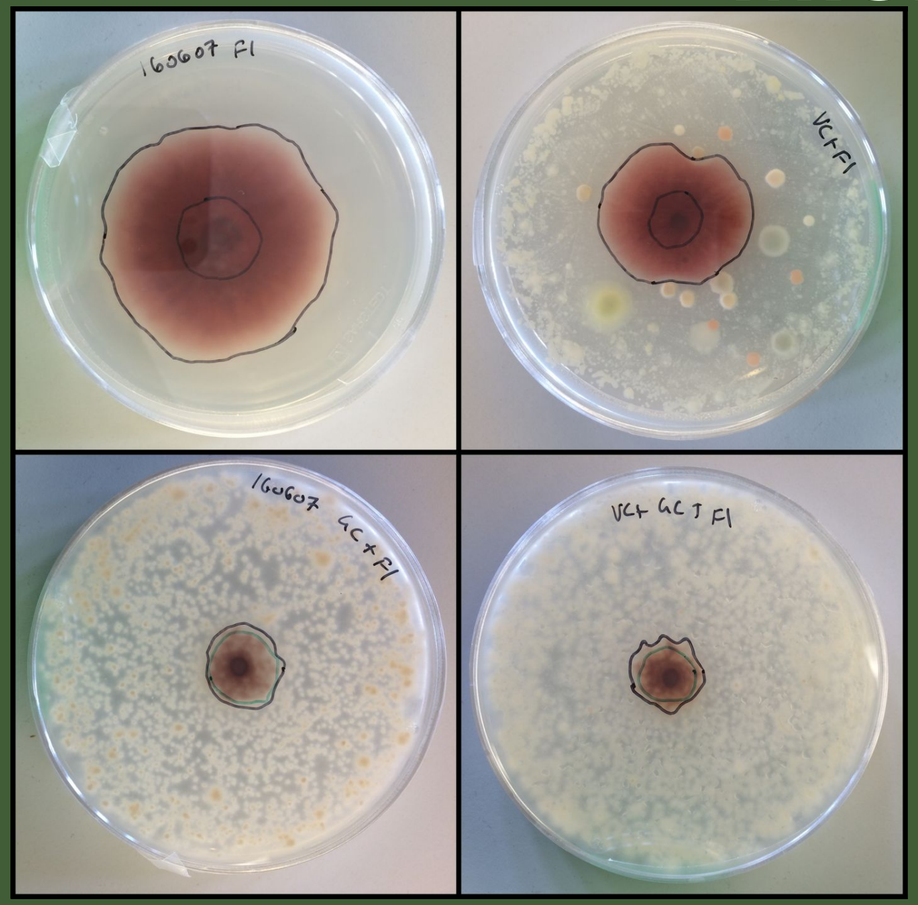


Roberts and Selitrennikoff 1968

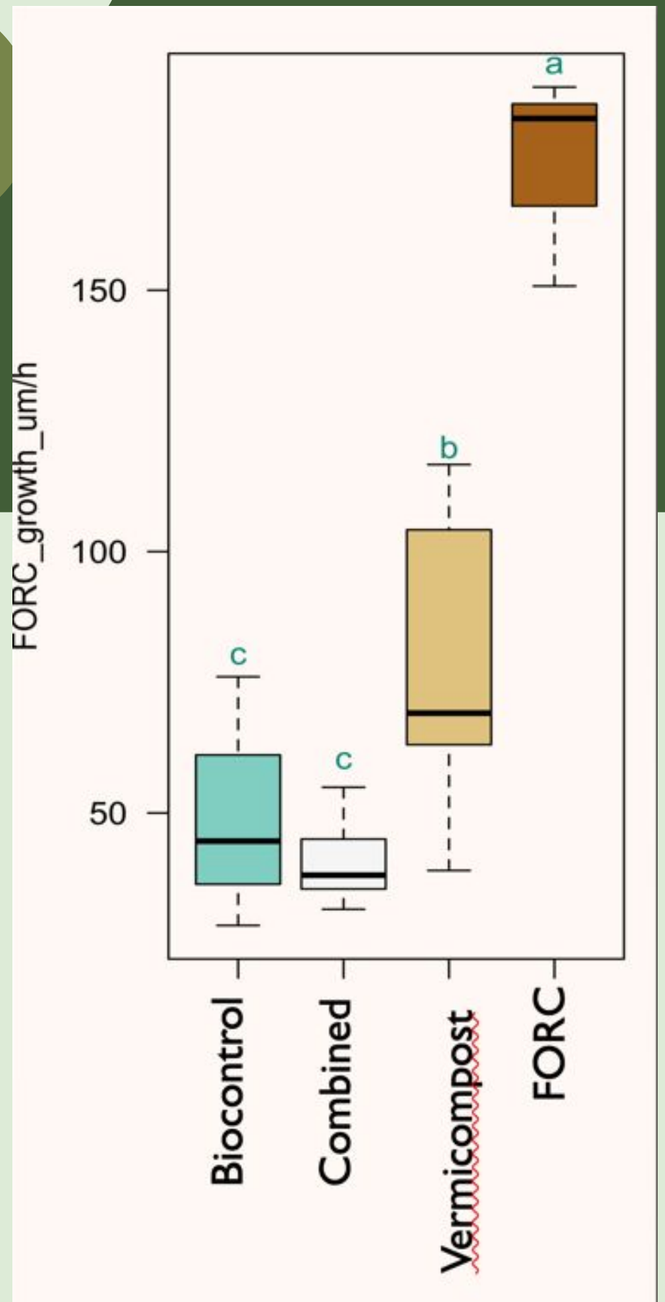
Practical Implementation of Microbial Biocontrol



Practical Implementation of Microbial Biocontrol

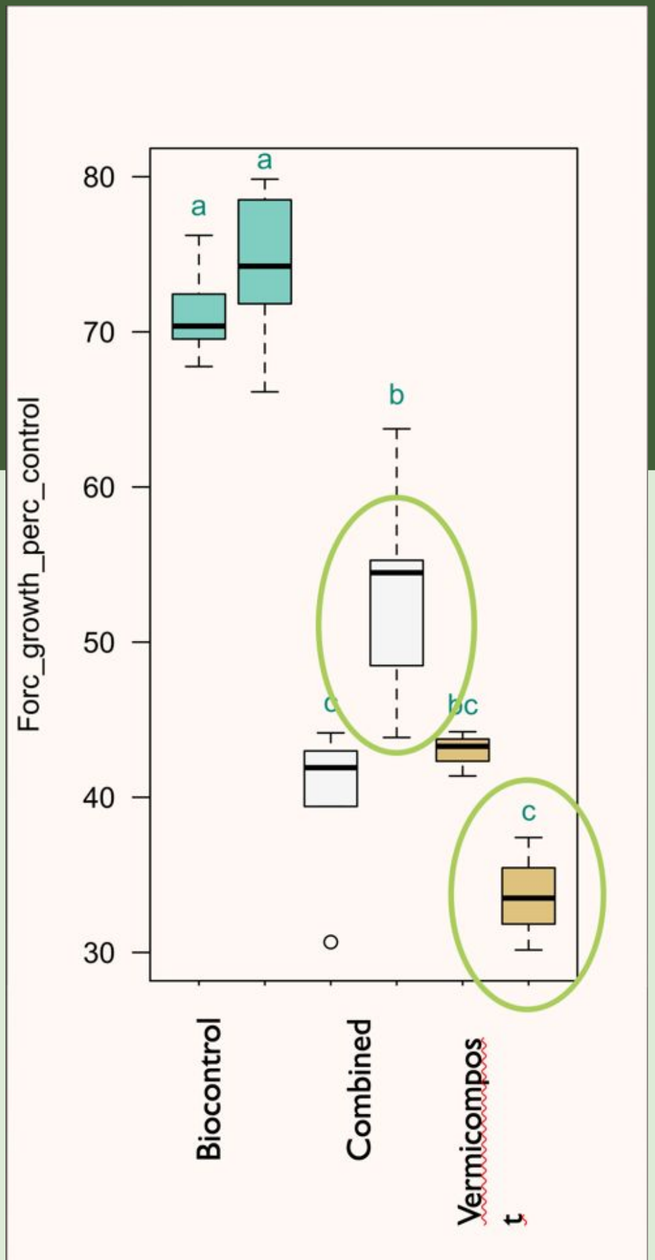


Practical Implementation of Microbial Biocontrol



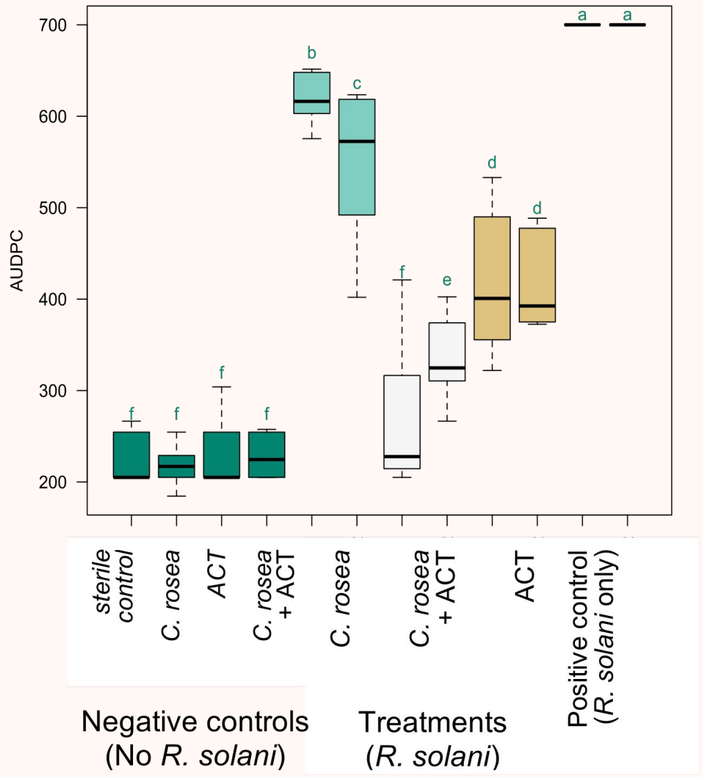
Combined data from three in vitro bioassay experiments comparing the growth of *Fusarium oxysporum f. sp. radicis-cucumerinum* (FORC) on 1/2 strength PDA alone, on a lawn of 48 h vermicompost tea (Vermicompost), on a lawn of *Clonostachys rosea f. catenulata* (*Gliocladium catenulatum*) strain J1446 (Prestop) (Biocontrol), and on a combined lawn of both vermicompost tea and Prestop (Combined). Means separated using

Combined data from two in vitro bioassay experiments comparing the growth of *Fusarium oxysporum f. sp. radicis-cucumerinum* (FORC) on 1/2 strength PDA alone, on a lawn of 48 h vermicompost tea (Vermicompost), on a lawn of *Bacillus subtilis* strain QST 713 (Rhapsody)(Biocontrol), and on a combined lawn of both vermicompost tea and Rhapsody (Combined). Means separated using Tukey's HSD test in N=30.



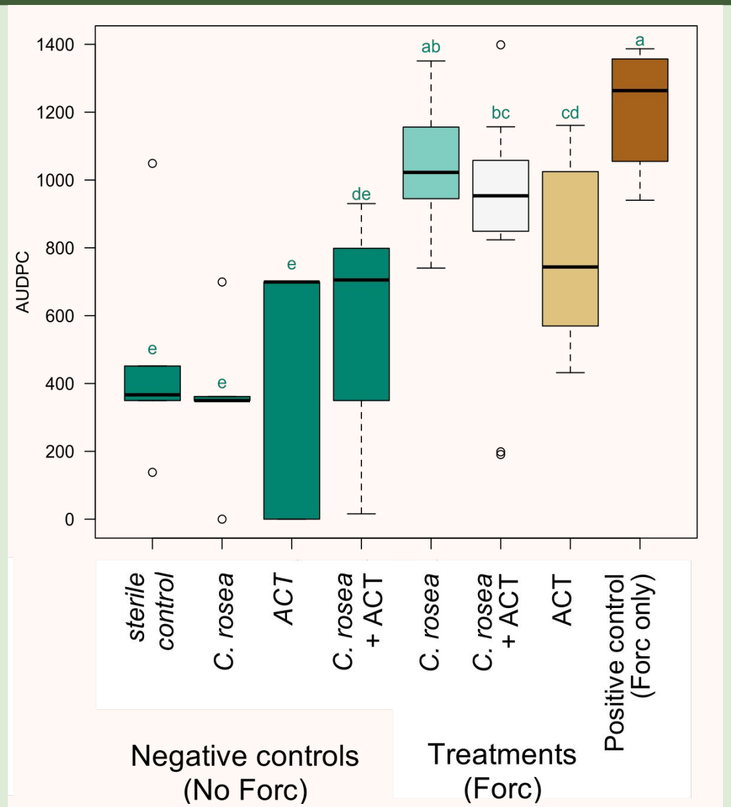
Practical Implementation of Microbial Biocontrol

RRC2: Growth chamber bioassay measuring the reduction in disease of radish caused by *Rhizoctonia solani* (*R. solani*) when treated with *Clonostachys rosea* f. *catenulata* (*Gliocladium catenulatum*) strain J1446 (Prestop®) (*C. rosea)* and/or aerated vermicompost tea (ACT).



Practical Implementation of Microbial Biocontrol

FCC2: Growth chamber bioassay measuring the reduction in disease of cucumber caused by *Fusarium oxysporum* f. sp. *radicis-cucumerinum* (Forc) when treated with *Clonostachys rosea* f. *catenulata* (*Gliocladium catenulatum*) strain J1446 (Prestop®) (*C. rosea*) and/or aerated vermicompost tea (ACT).



Practical Implementation of Microbial Biocontrol

Summary results of four sets of experiments testing the disease suppressive effects of biocontrol agents *Bacillus subtilis* strain QST 713 (Rhapsody) and *Clonostachys rosea f. catenulata* (*Gliocladium catenulatum*) strain J1446 (Prestop®) on the pathogens *Fusarium oxysporum* f. sp. *radicis-cucumerinum* (Forc) and *Rhizoctonia solani* on cucumber and radish.

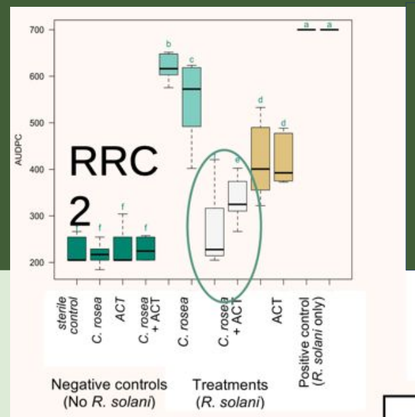
Pathogen/host/biocontrol	Experiment	AUDPC % reduction		
		BC agent	Vermicompost	Combined
R. solani/radish/*C. rosea*	RRC1	42 a	50 a	36 a
	RRC2	25 a	60 b	84 c
R. solani/radish/*B. subtilis*	RRB1	0 a*	89 b	96 b
	RRB2	0 a*	60 b	61 b
Forc/cucumber/*C. rosea*	FCC1	57 a	64 a	74 a**
	FCC2	22 a*	58 a**	44 a*
Forc/cucumber/*B. subtilis*	FCB1	61 a	64 a	64 a
	FCB2	-5 a*	50 b	93 c**, 47 b

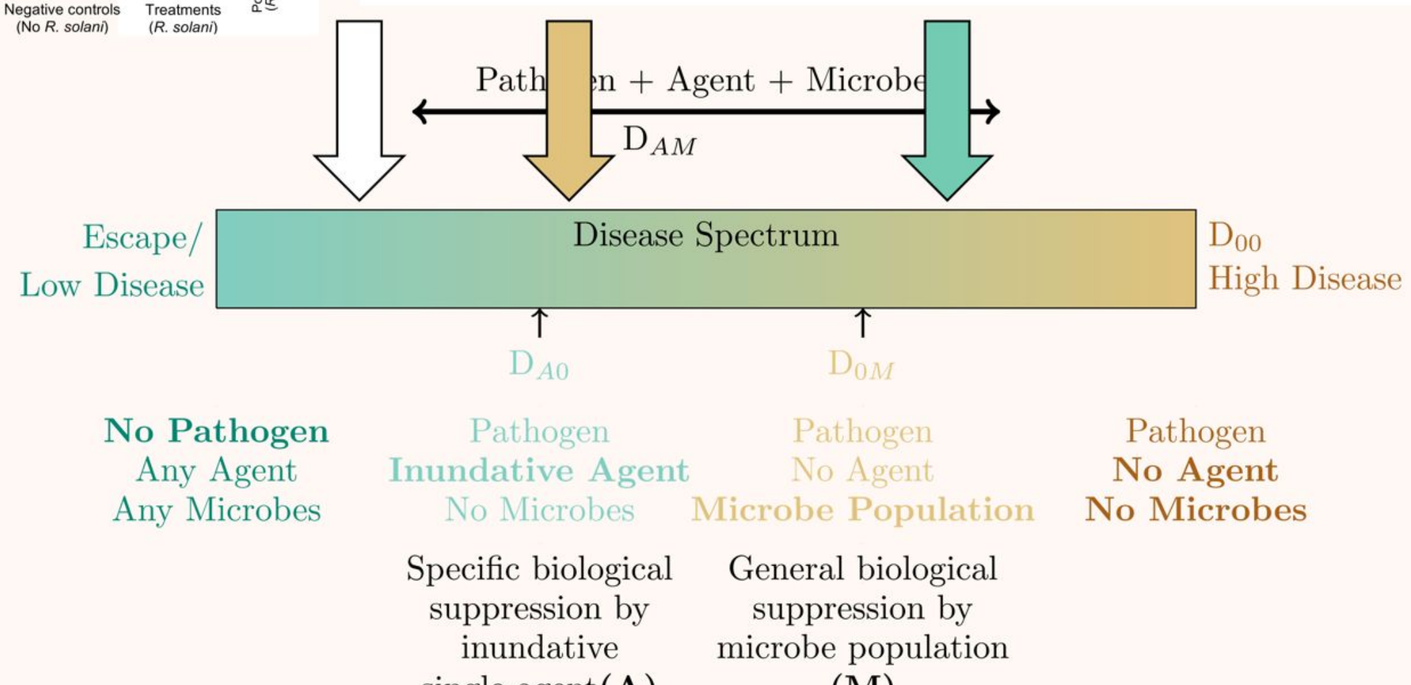
Different letters indicate that treatment means could be separated according to Tukey's HSD test, P<0.05.
Disease reduction was significant unless indicated by *.
Double values indicate that repeated experiment means differed according to Tukey's HSD and could not be combined.
**indicates that this treatment could not be separated from the negative (no pathogen) control treatments.

Practical Implementation of Microbial Biocontrol

Experiment	Biocontrol	Experiment code[3],	Pathosystem	Interaction +/-, Effect size, SE	Interaction type
In vitro	C. rosea	IA1, 4.3	n/a	+, 88.8, 14.5	Antagonistic
	B. subtilis	IA2, 4.2	n/a	+, 53.9, 16.2	Antagonistic
In planta	C. rosea	RRC1, 4.5	Radish / *Rhizoctonia*	+, 198, 50.4	Antagonistic
		RRC2, 4.6		-, 1.96, 48.4	Additive
		FCC1, 4.9	Cucumber / Forc	+, 305, 80.9	Antagonistic
		FCC2, 4.10		-, 267, 228	Neutral
	B. subtilis	RRB1, 4.7	Radish / *Rhizoctonia*	-, (-37.8, 17.8)	Neutral
		RRB2, 4.8		-, (-4.92, 27.9)	Neutral
		FCB1, 4.11	Cucumber / Forc	+, 195, 59.9[1]	Antagonistic
		FCB2, 4.12		+, 216, 226	Additive[2]

Practical Implementation of Microbial Biocontrol





Conclusion

- Microbial biocontrol is experiencing technological, ecological, and data driven breakthroughs – these will be tempered by field implementation
- Entomological systems provide models for regulatory, operational, and ecological robustness that microbial biocontrol can emulate.
- The next wave of microbial biocontrol research will require cross-disciplinary collaboration, advanced tools, and holistic systems science.

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Thank you!

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