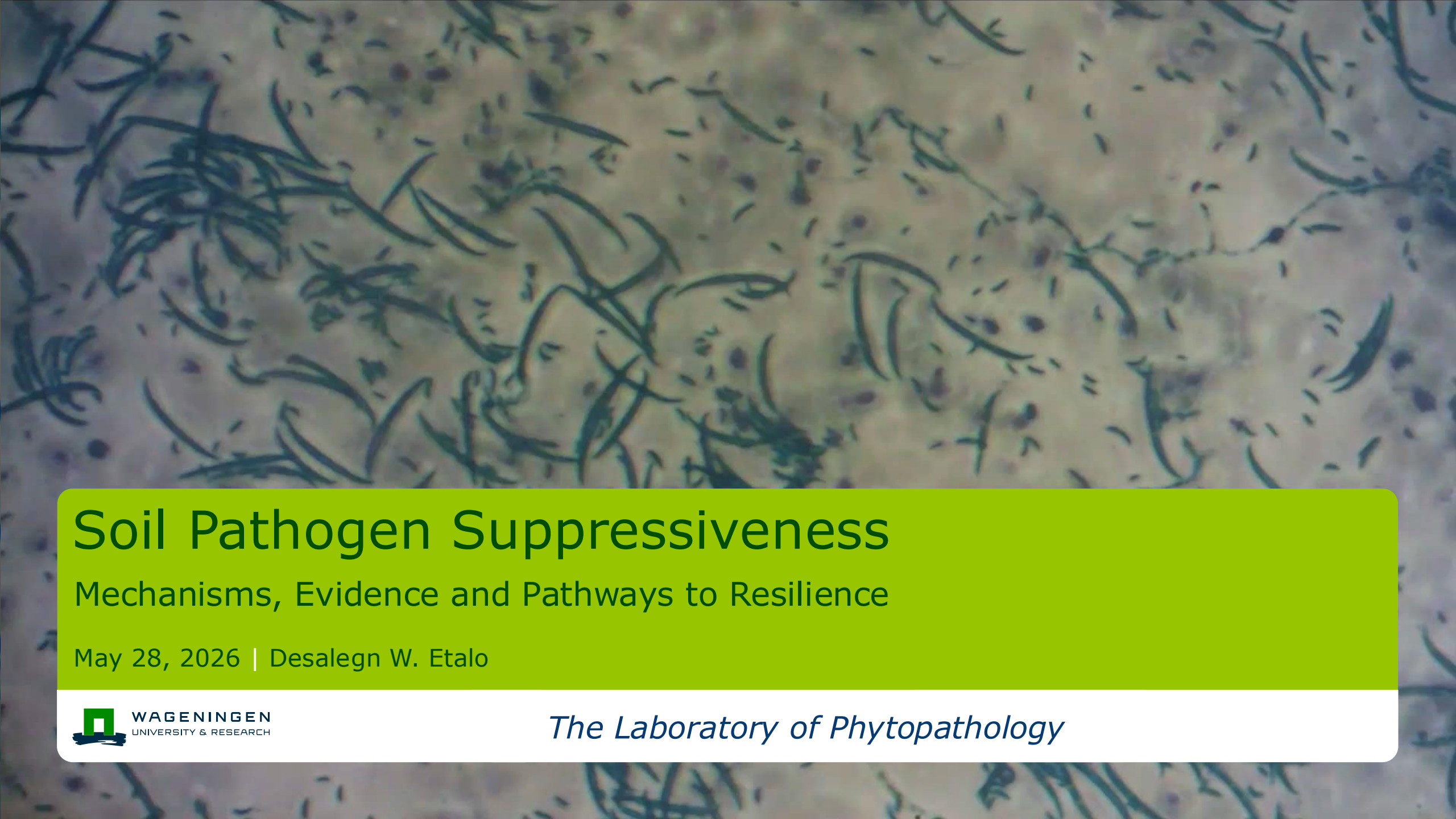

Soil Pathogen Suppressiveness

Mechanisms, Evidence and Pathways to Resilience

May 28, 2026 | Desalegn W. Etalo

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The Laboratory of Phytopathology

The paradox in plant health

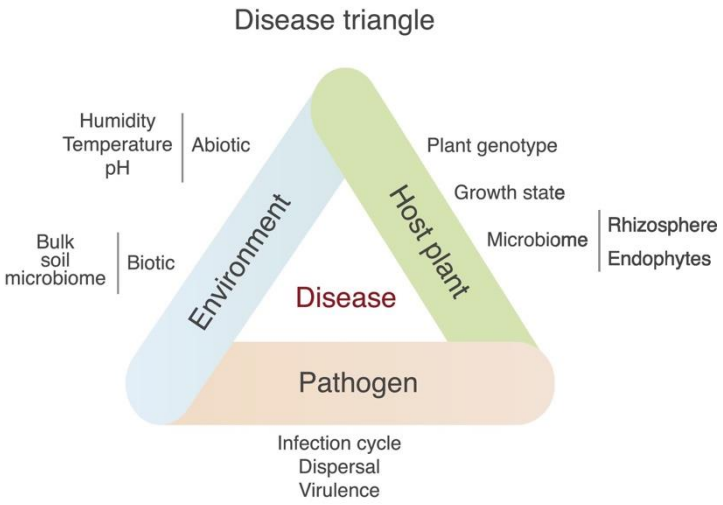
Why does the same pathogen cause severe disease in one soil but not in another?

Healthy field (suppressive soils)

Limited symptoms and plants remain productive

Diseased field (conducive soils)

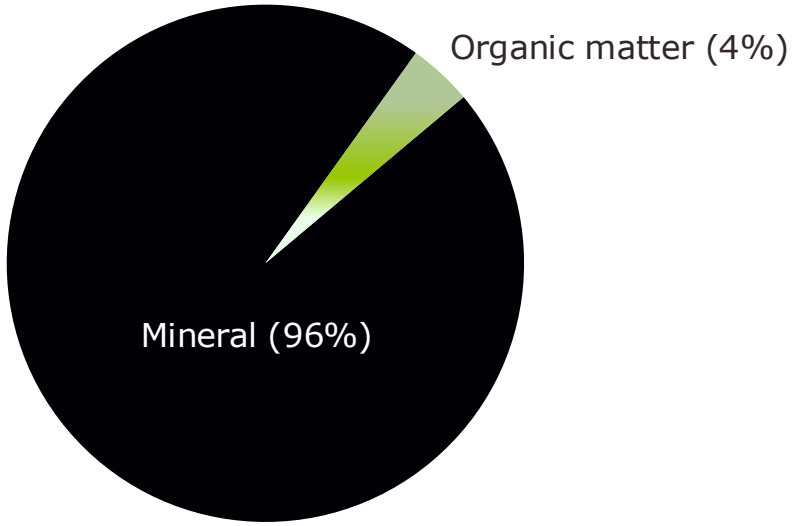
Severe disease and low productivity



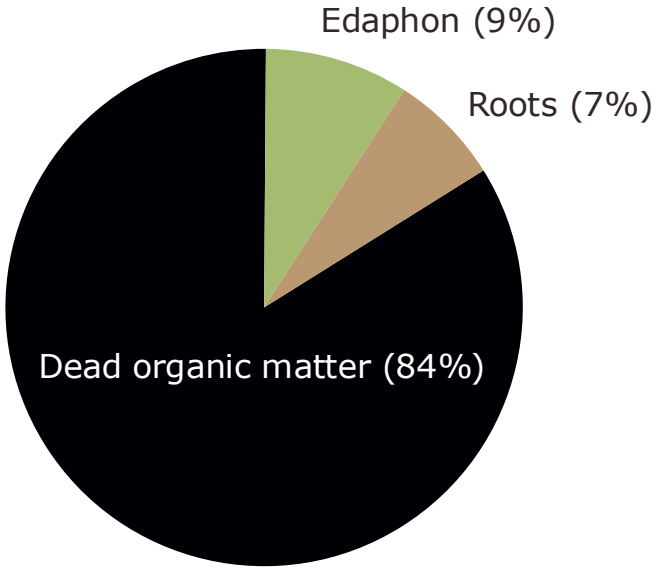
DOI: 10.1016/j.tplants.2020.01.007

Soil: where it all starts

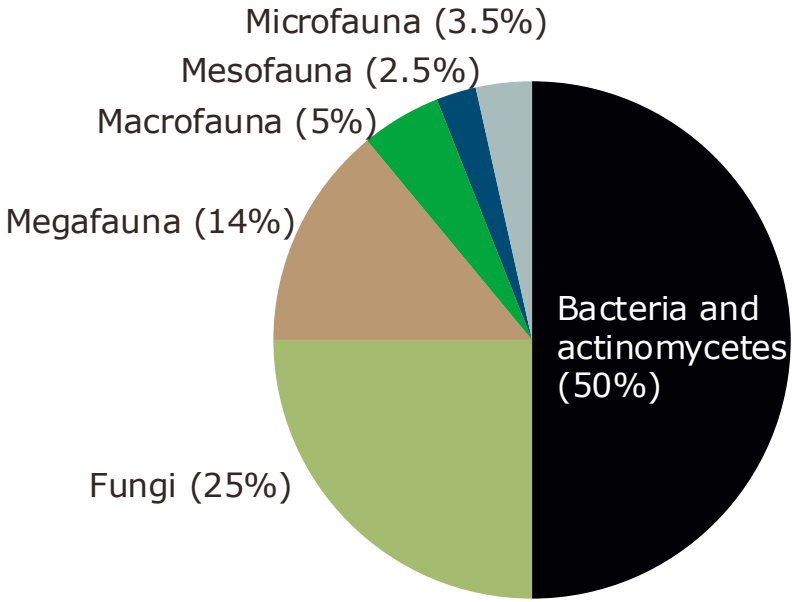
Soil



Organic matter



Edaphon



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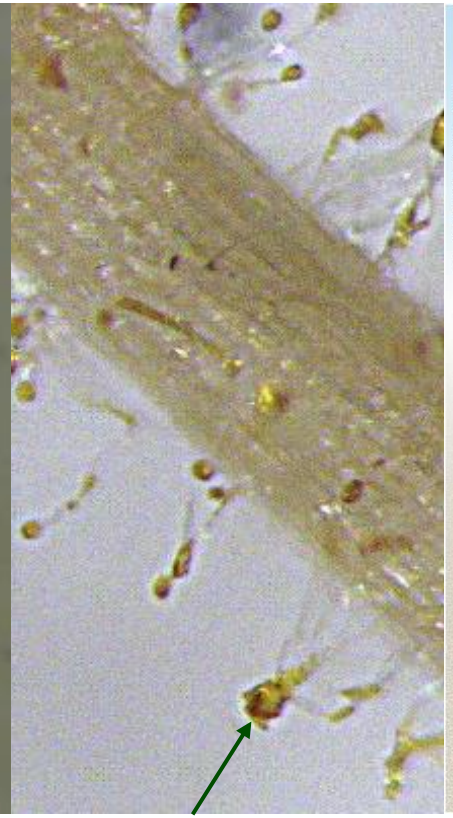
Plants do not build microbiomes from scratch — they recruit from soil.

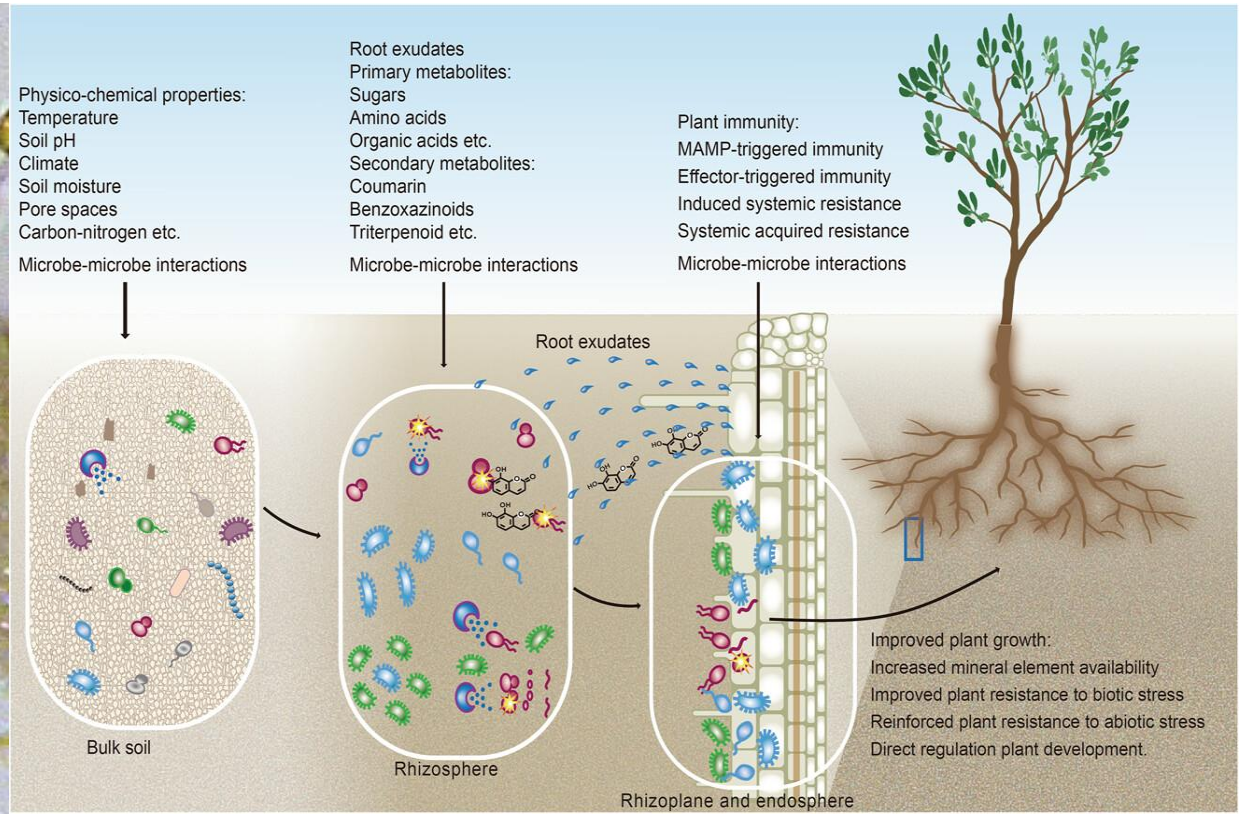
Microbiome assembly

Attraction and assimilation

Flocking microbes (video)



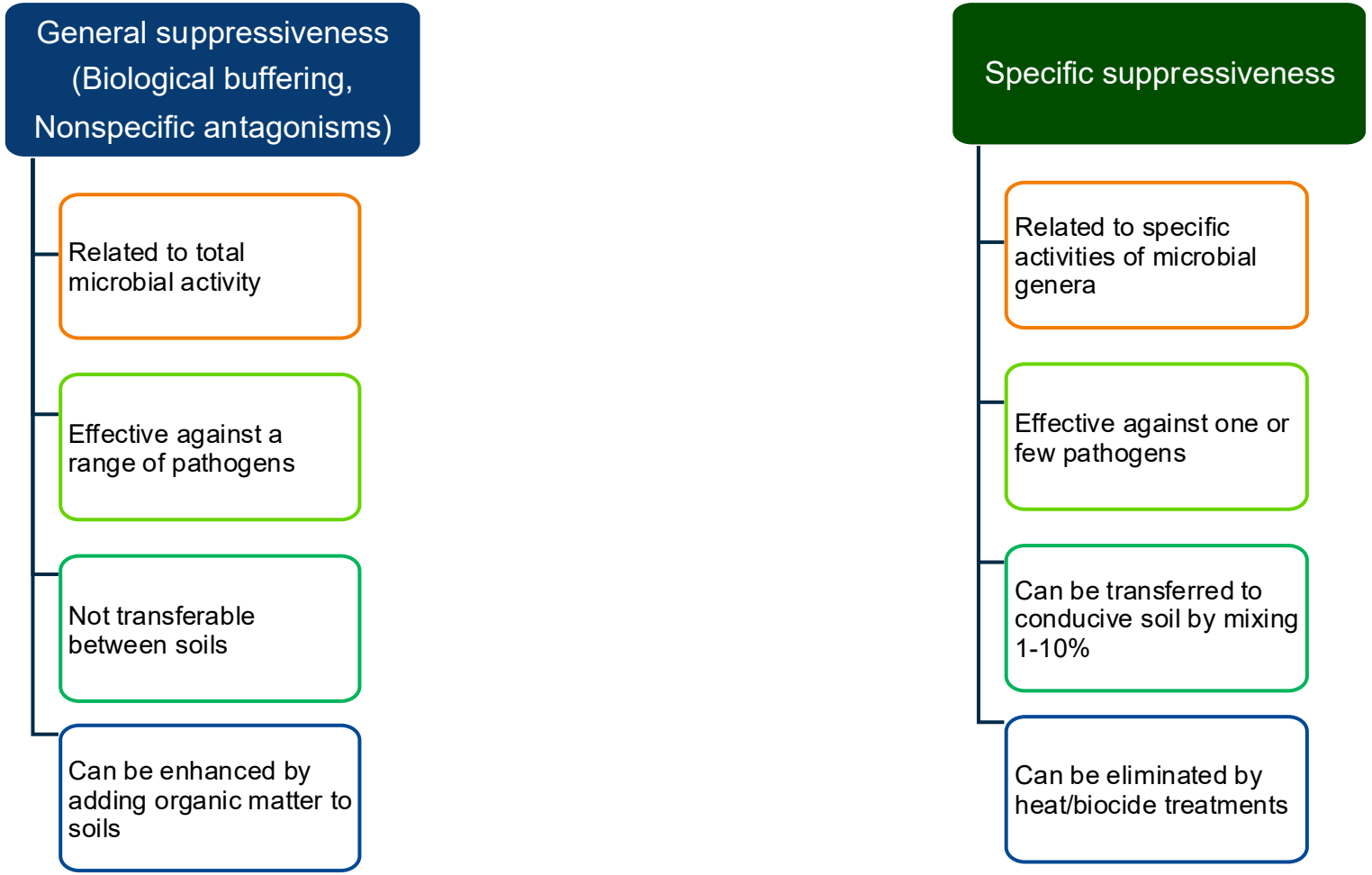
Root exudate



DOI:10.1111/jipb.13226

Root exudates act as “fishing nets” for microbes.

Two types of soil suppressiveness to pathogens

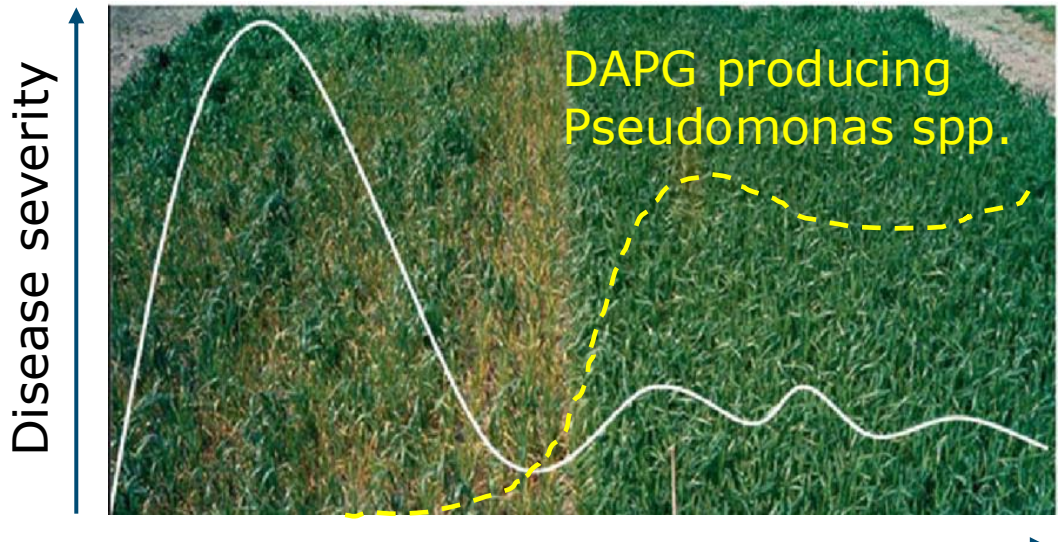


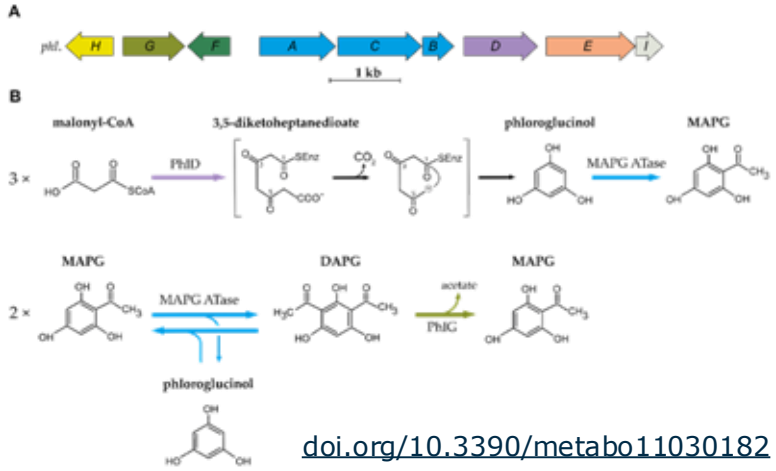
General = community-level buffering Specific = key taxa-driven suppression

Take-all-decline (TAD)-Specific suppression

cropscience.bayer.co.uk/take-all

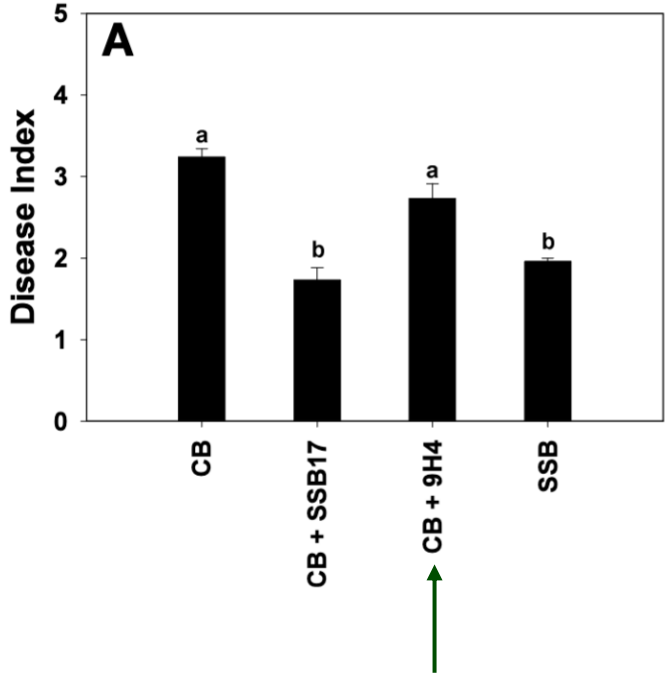
Caused by Gaeumannomyces tritici





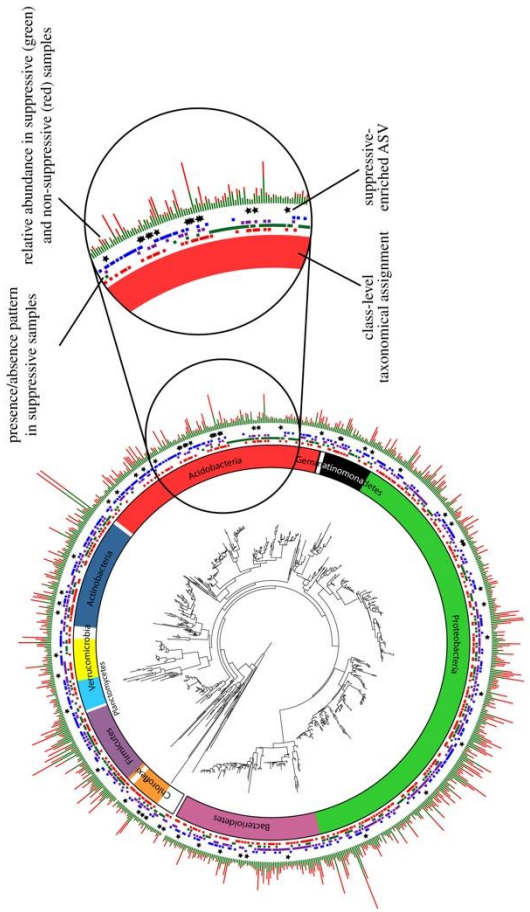
doi.org/10.3390/metabo11030182

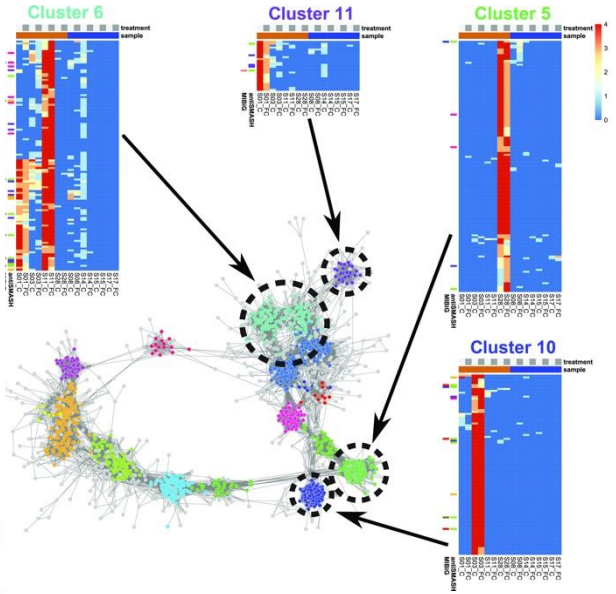
de Souza et al. 2003



DAPG-deficient mutant

Disease suppressive functions in soil-metagenome

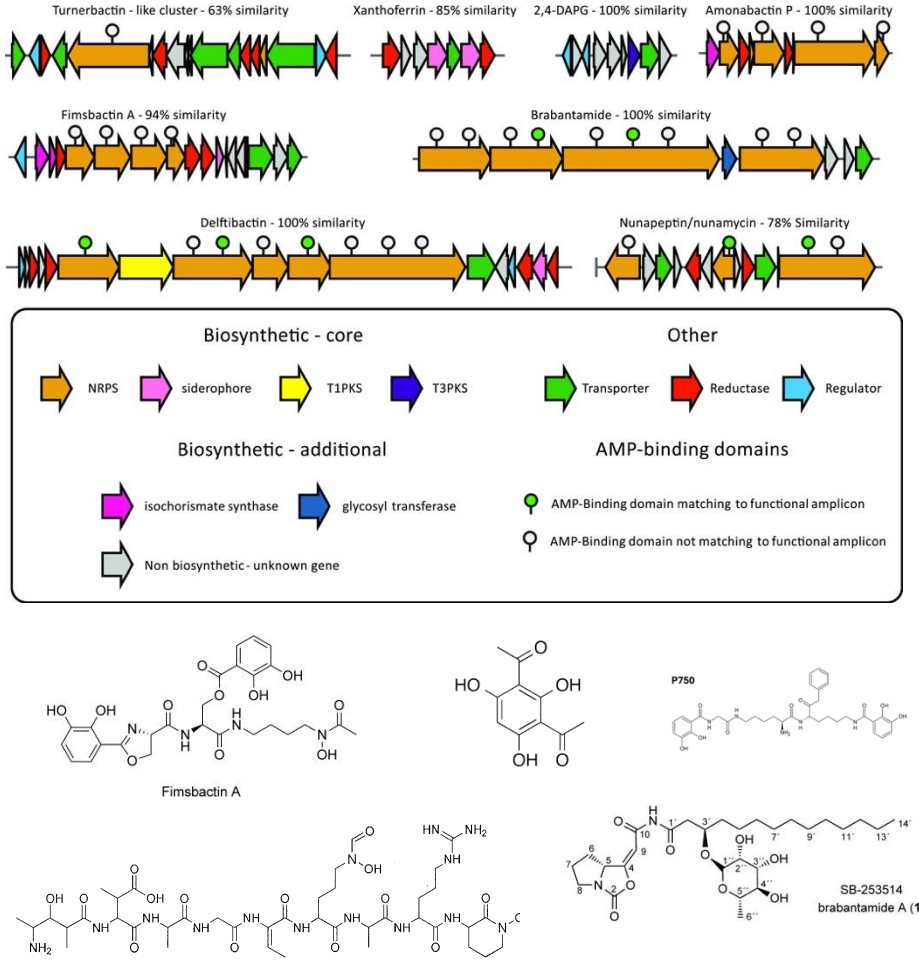




sample
- inoculated
- non inoculated
- suppressive
- conducive

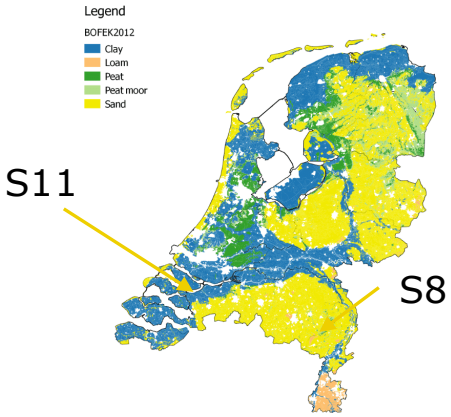
antiSMASH
- lipopeptide
- nrps
- other_hybrid
- t1pks−nrps

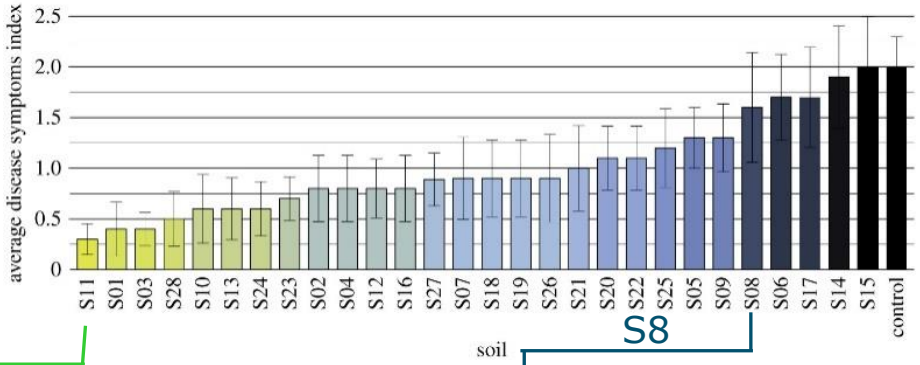
MIBiG
- pyoverdin
- delftibactin A
- cysteoamide
- salinichelins
- syringomycin
- syringopeptin
- ornibactin



https://doi.org/10.1128/mSystems.01116-20

Culturomics to unravel disease suppressive agents



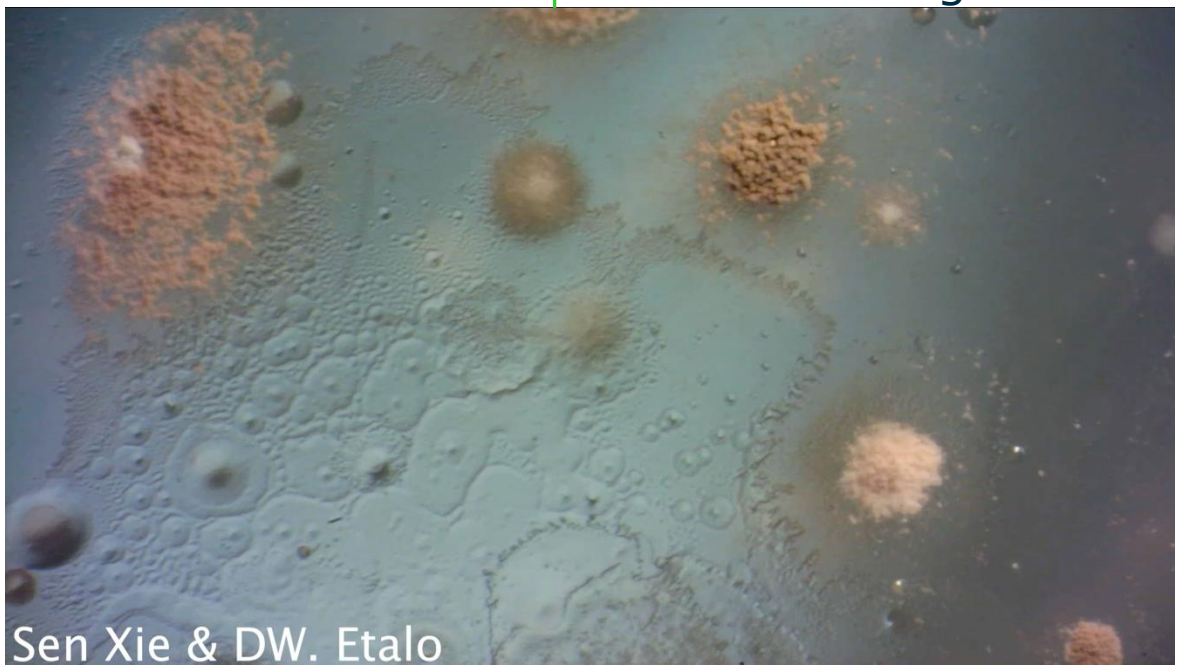


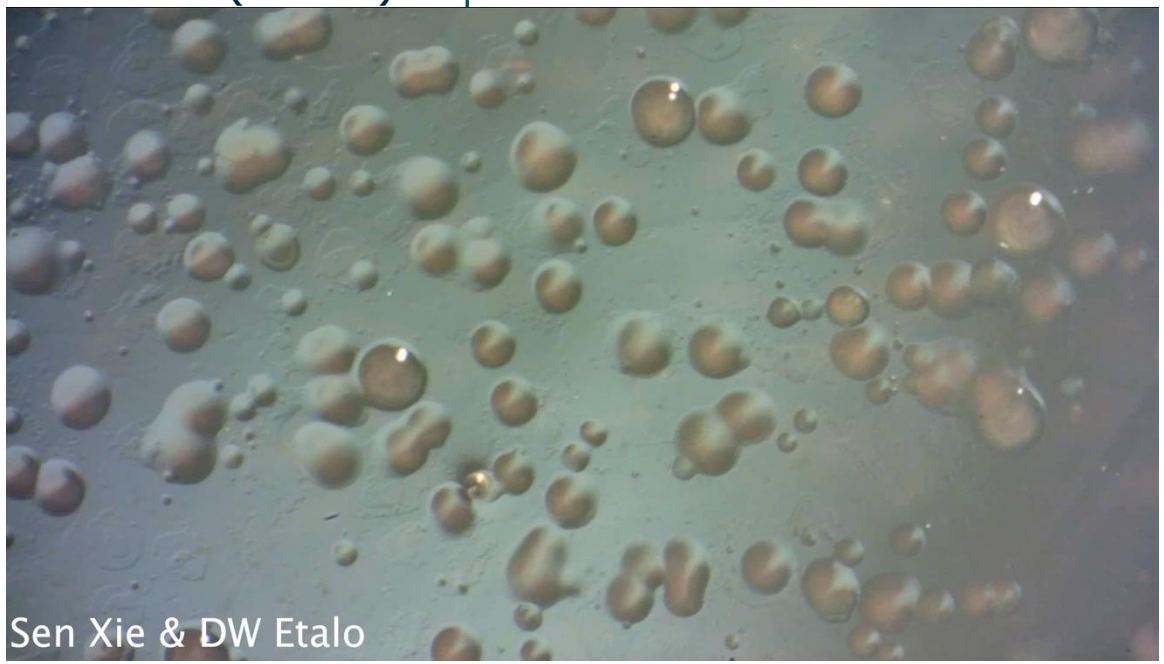
S11

S8

Ossowick et al., 2020

Footage of soil microbes (video)





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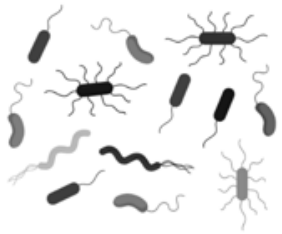
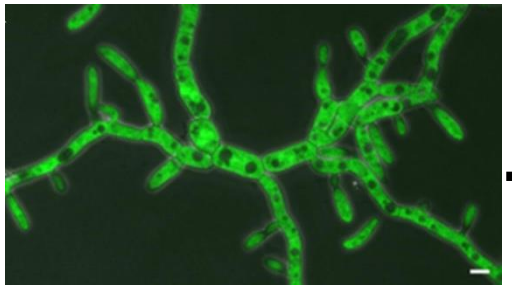
Which microbes matter, more importantly, which functions actually suppress disease?

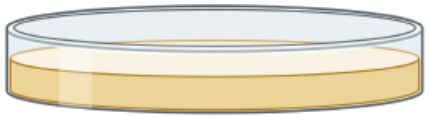
From soil microbiome to functional antagonist



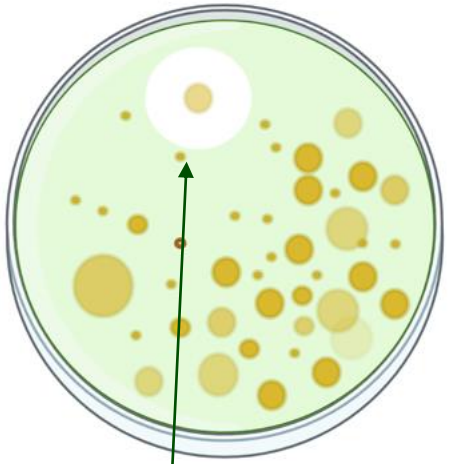
Soil microbiome



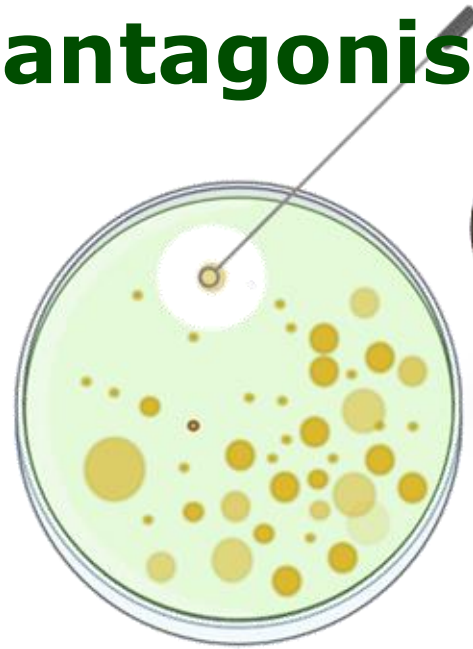
Gfp Fusarium



Unlock medium



Zone of inhibition



Selection and purification

few weeks

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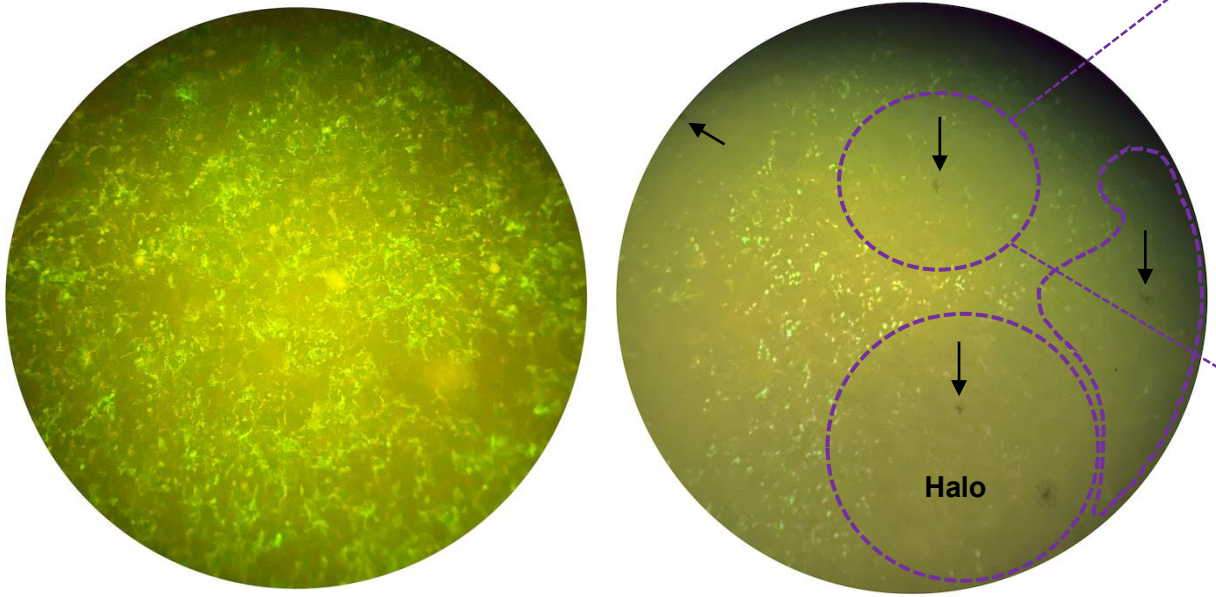
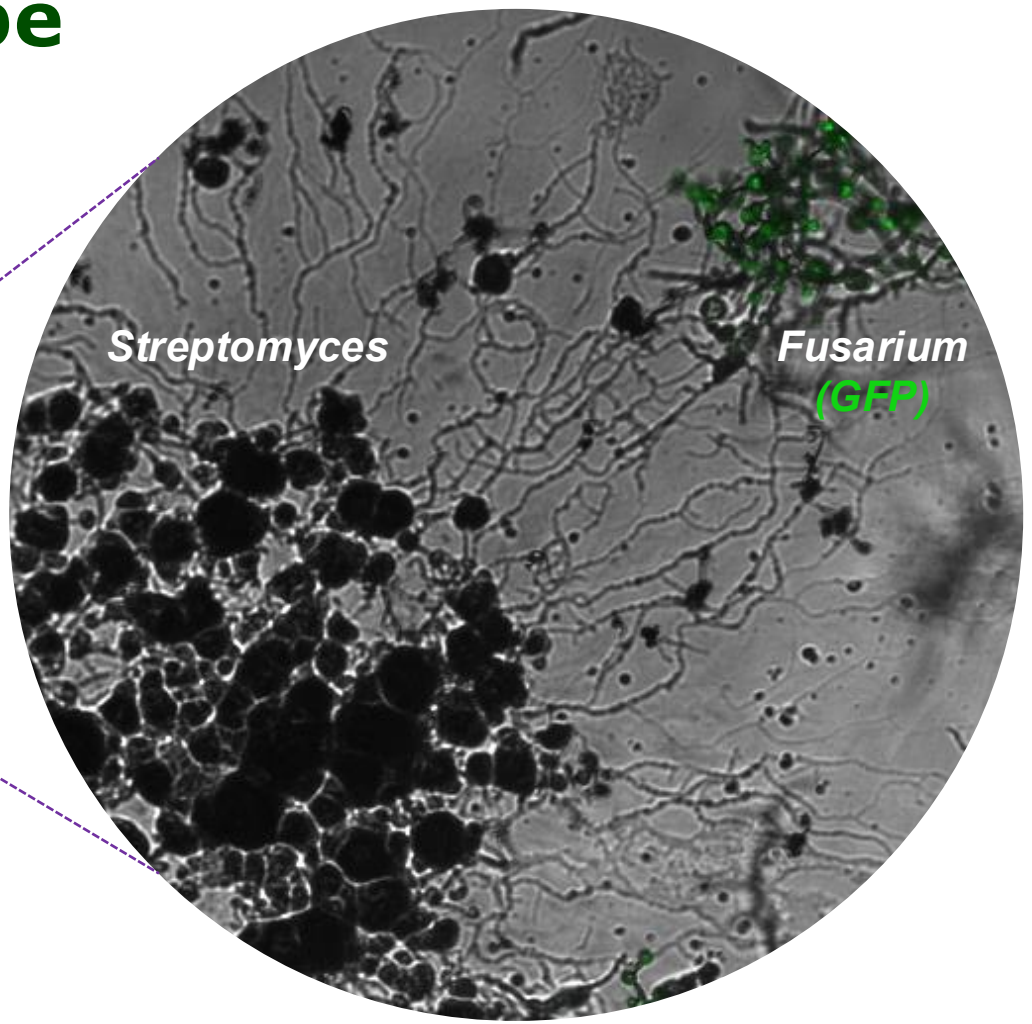
Culturomics enabled us to culture substantially higher number of soil microbes

Function-guided culturomics to isolate disease suppresive microbe

S08 (Conducive soil)

S11 (Suppressive soil)



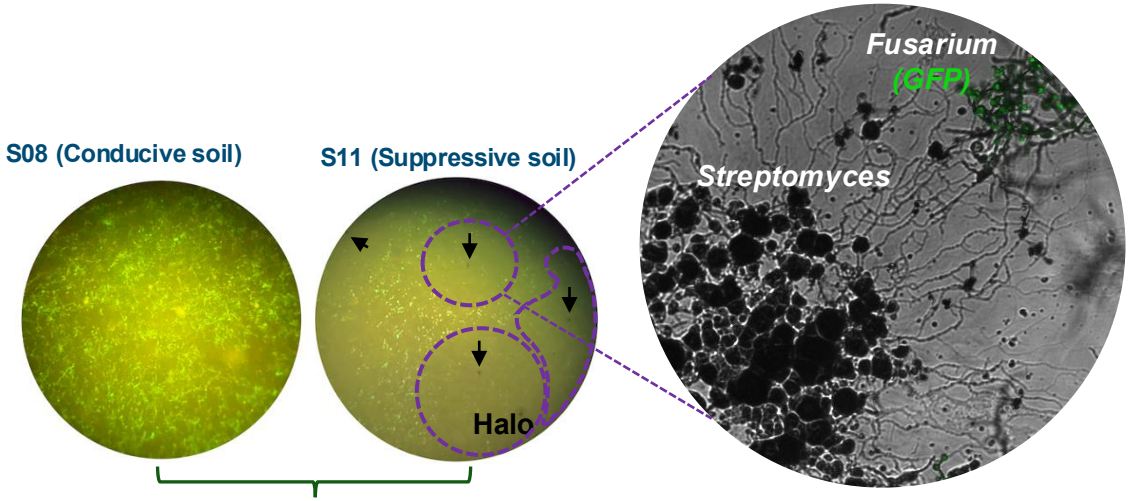


Co-cultivation of soil microbiome and Fusarium (GFP-tagged)

Confocal microscopy

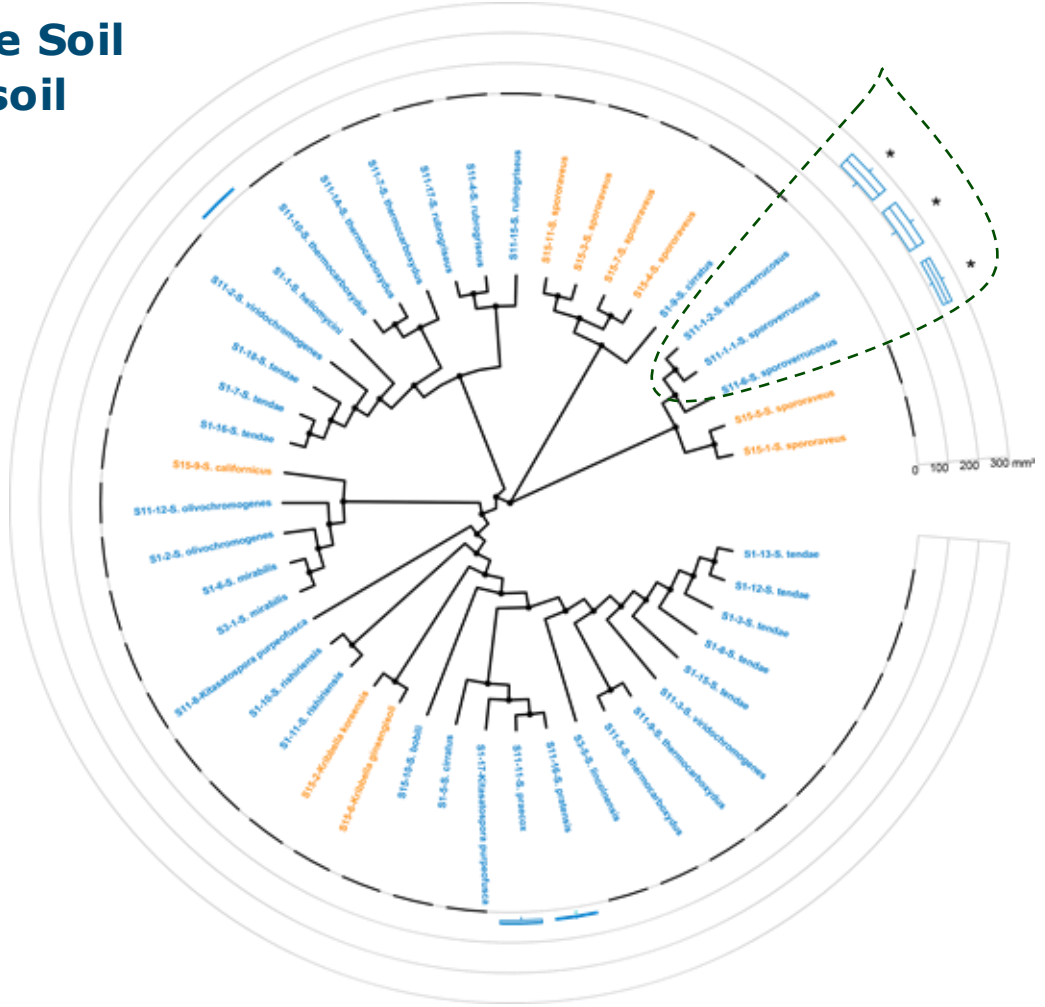
Actinomycetes antagonistic phylogenetic signal

Suppressive Soil
Conducive soil



Co-cultivation of soil microbiome and Fusarium

Confocal microscopy



Fusarium suppression

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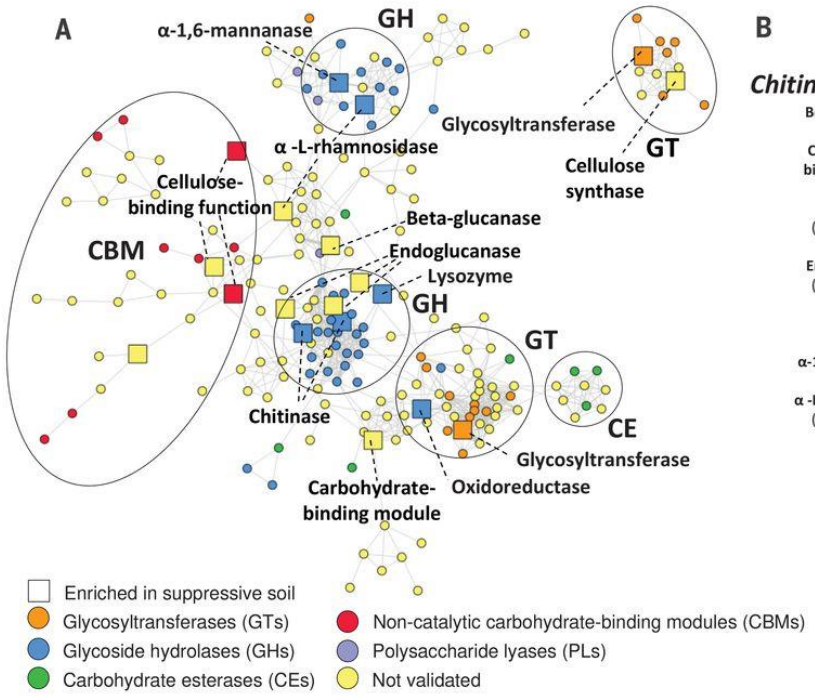
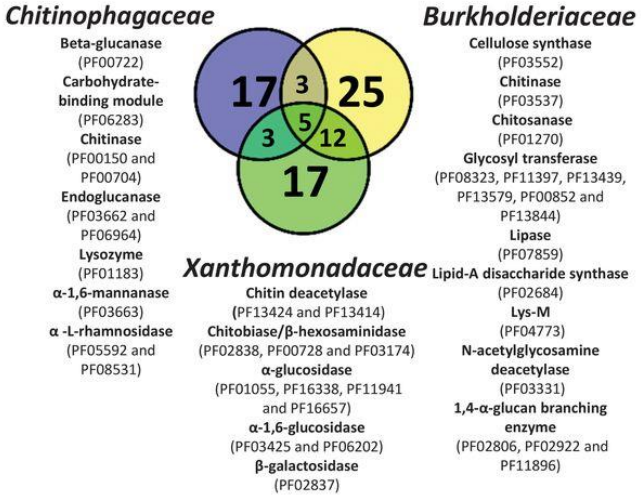
Disease suppression is not about who is there, but what they do.

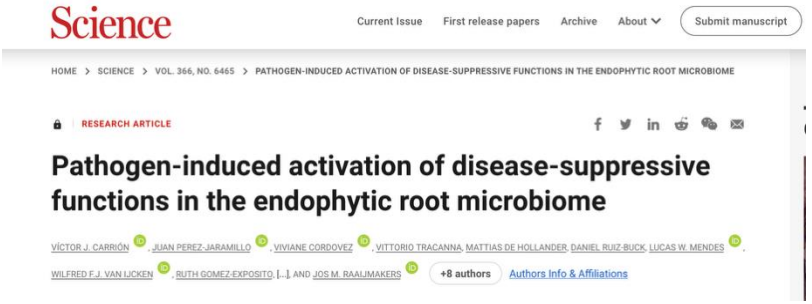
Suppressive soils reshape the internal plant microbiome

Suppressive soil (DSI ~30) Conducive soil (DSI>80)

- DSI-disease severity index
- Susceptible host
- Virulent pathogen

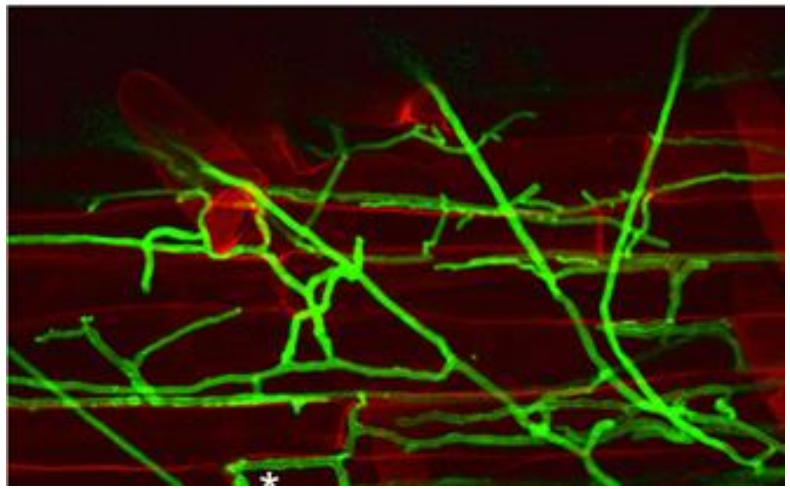


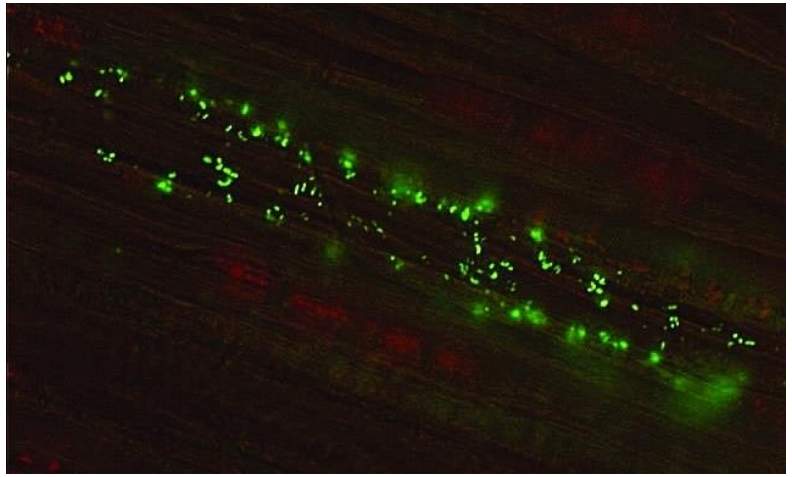




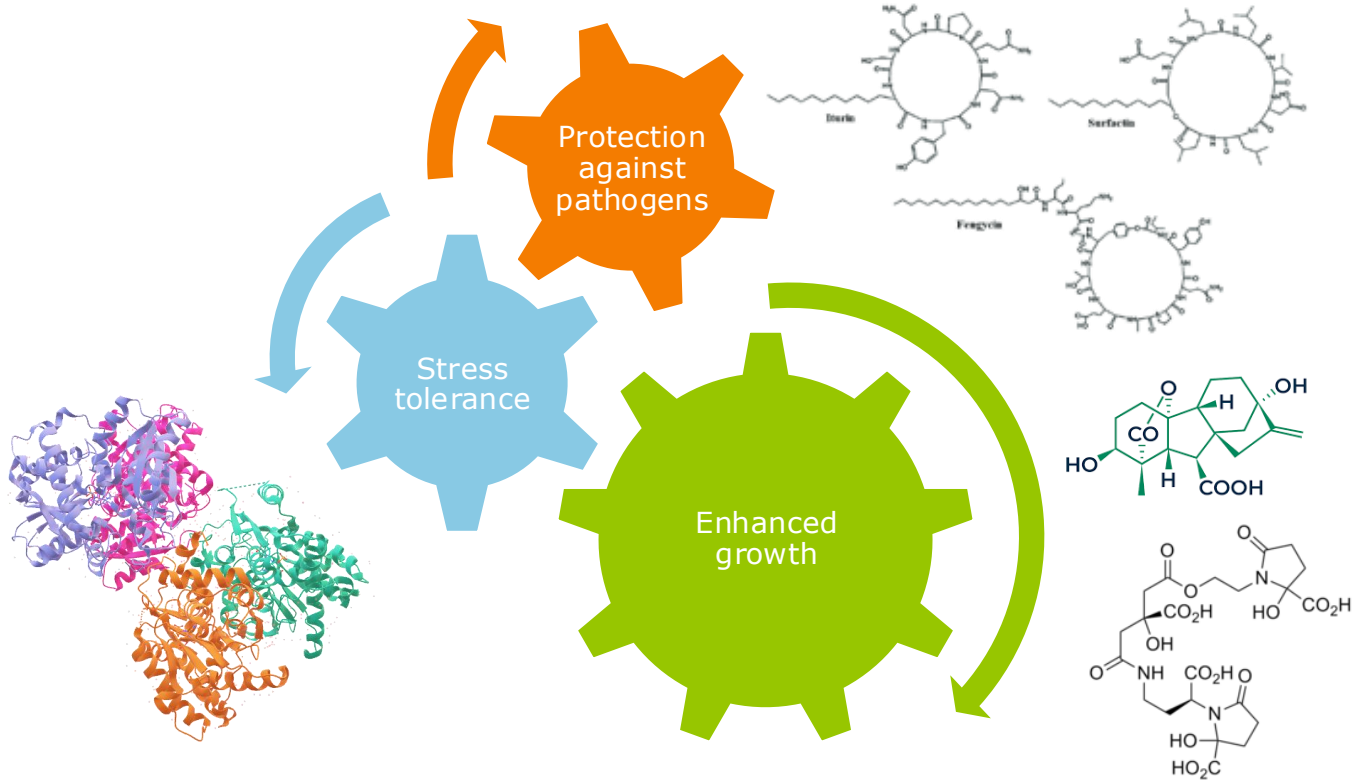
Suppressive soils recruit protective endophytes and functions.

Harnessing endophytes for pathogen suppression





- Endophytes are microorganisms, such as bacteria or fungi, that live inside plant tissues without causing apparent harm.



Suppressive soils recruit protective endophytes and functions.

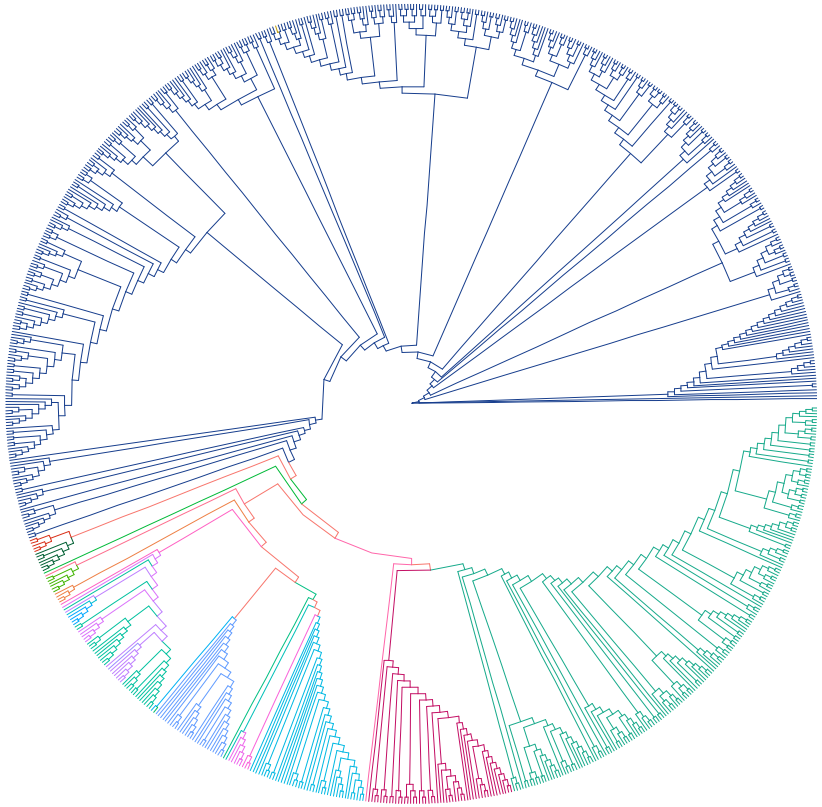
Endophytes as a plant ally to counter fast evolving pathogen

Convenience and consumers' demand

Sexual and clonal

Pathogens evolve faster than our control strategies.

Diverse endophyte collections to study disease suppressive functions



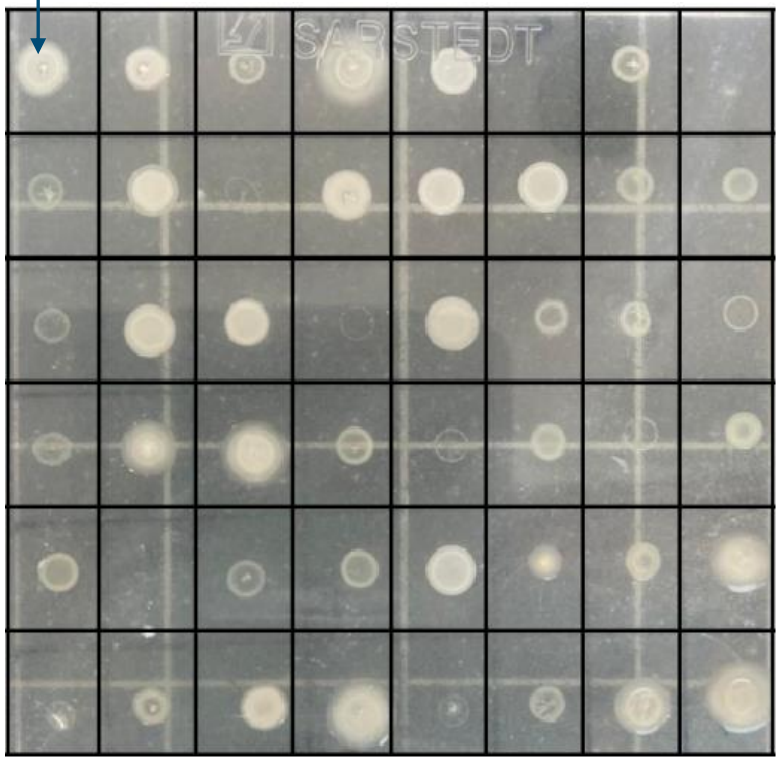
Over 1,300 endophytic isolates were collected from wild and domesticated banana and Enset plants. How can we evaluate their antagonistic potential against major banana pathogens?

Endophytes bridge the evolutionary gap between plants and fast-evolving pathogens.

High-throughput screening for pathogen suppression

Endophyte spot inoculation

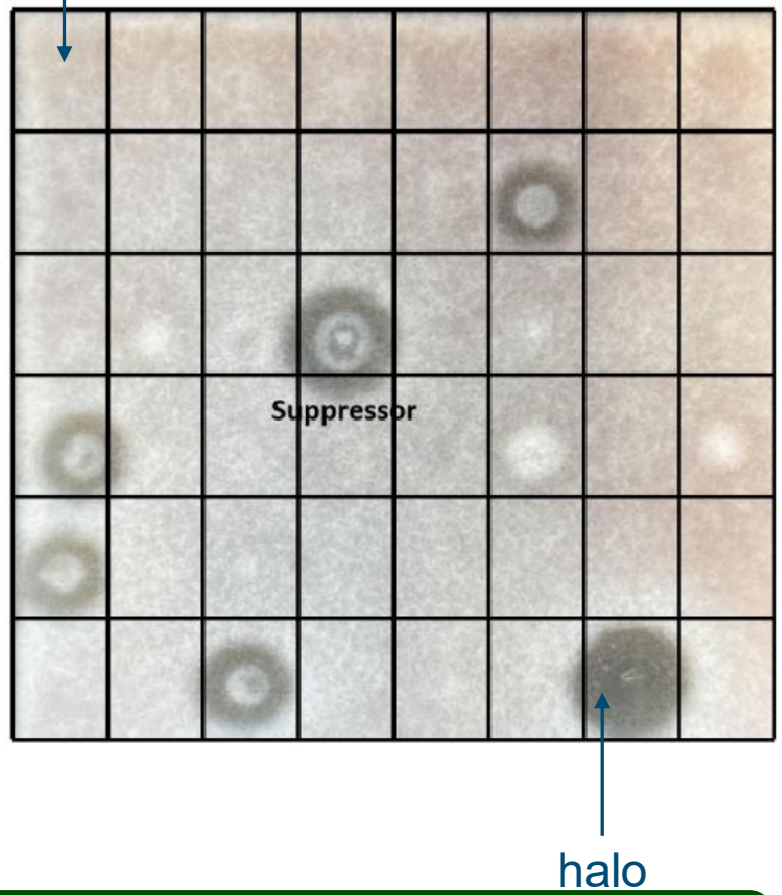
1 dpi



- Mix Fusarium spore with media (1 dpi)
- Spot inoculate the endophyte (1 dpi)
- Observe for inhibition zones (halo) 5 dpi

Fusarium

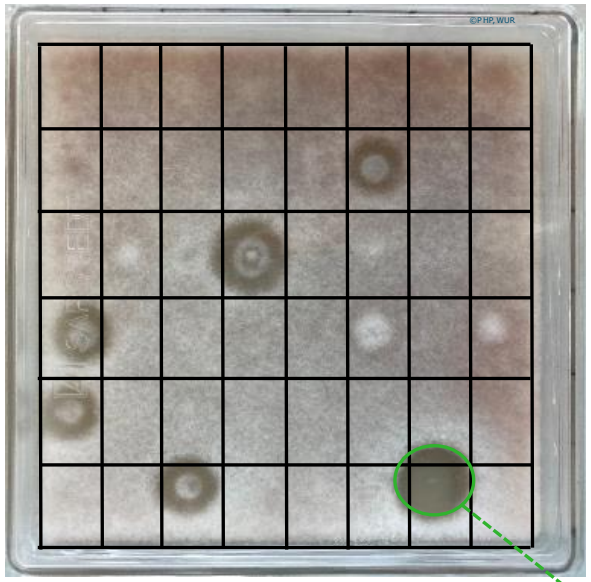
5 dpi



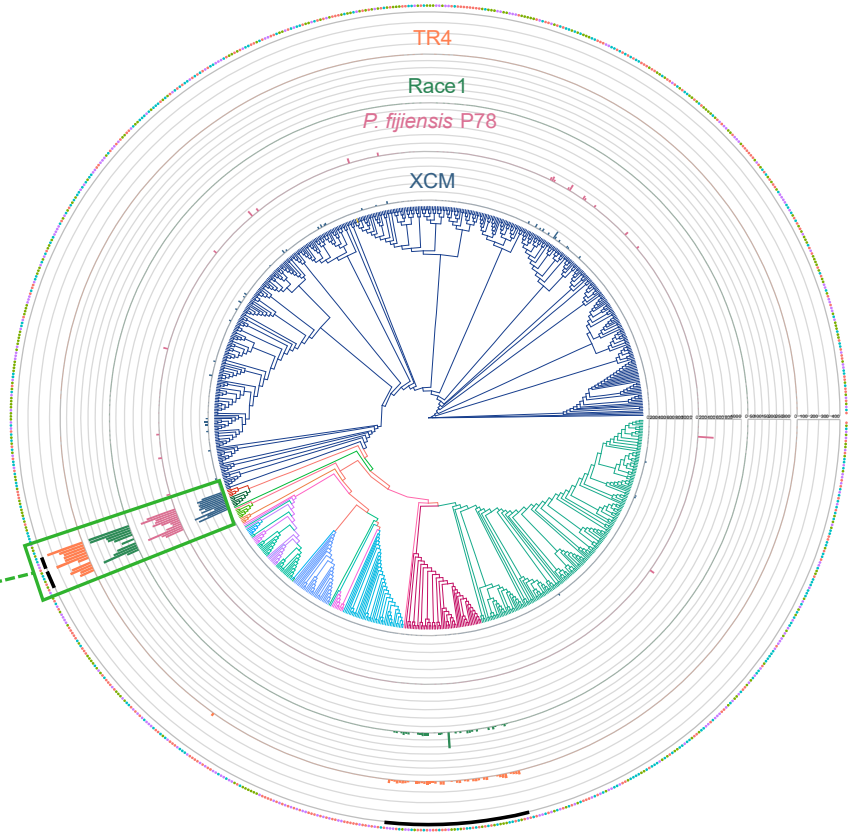
Weizheng Peng

Endophytic cross-kingdom antagonistic signal

Margherita Berri



Strong cross-kingdom antagonistic signal



Fusarium (TR4/Race1)

P.fijiensis

Xanthomonas campestris (Xcm)

Banana pathogens

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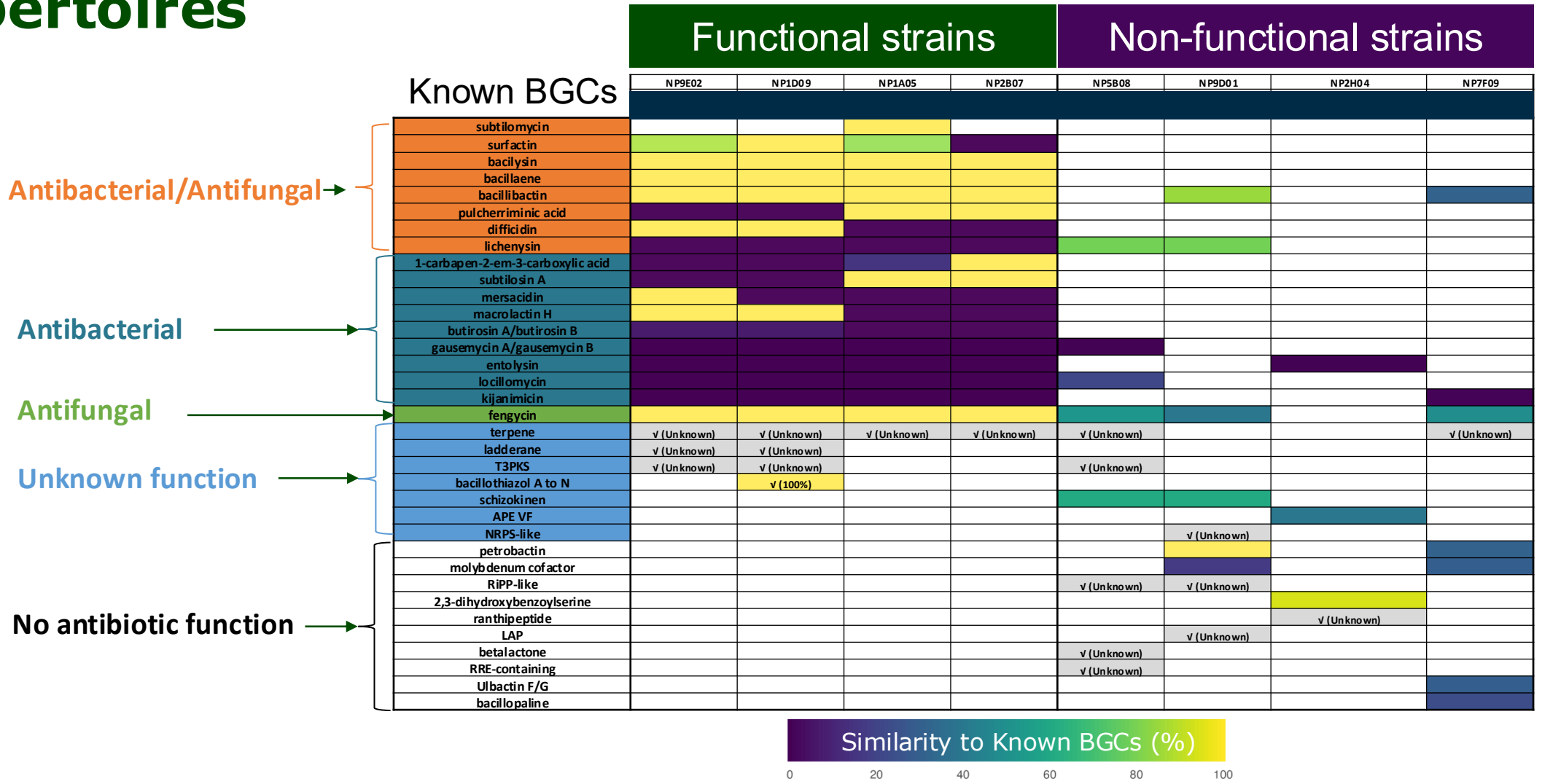
Antagonism is not random — it is evolutionarily structured.

Functional endophytes share conserved antimicrobial repertoires



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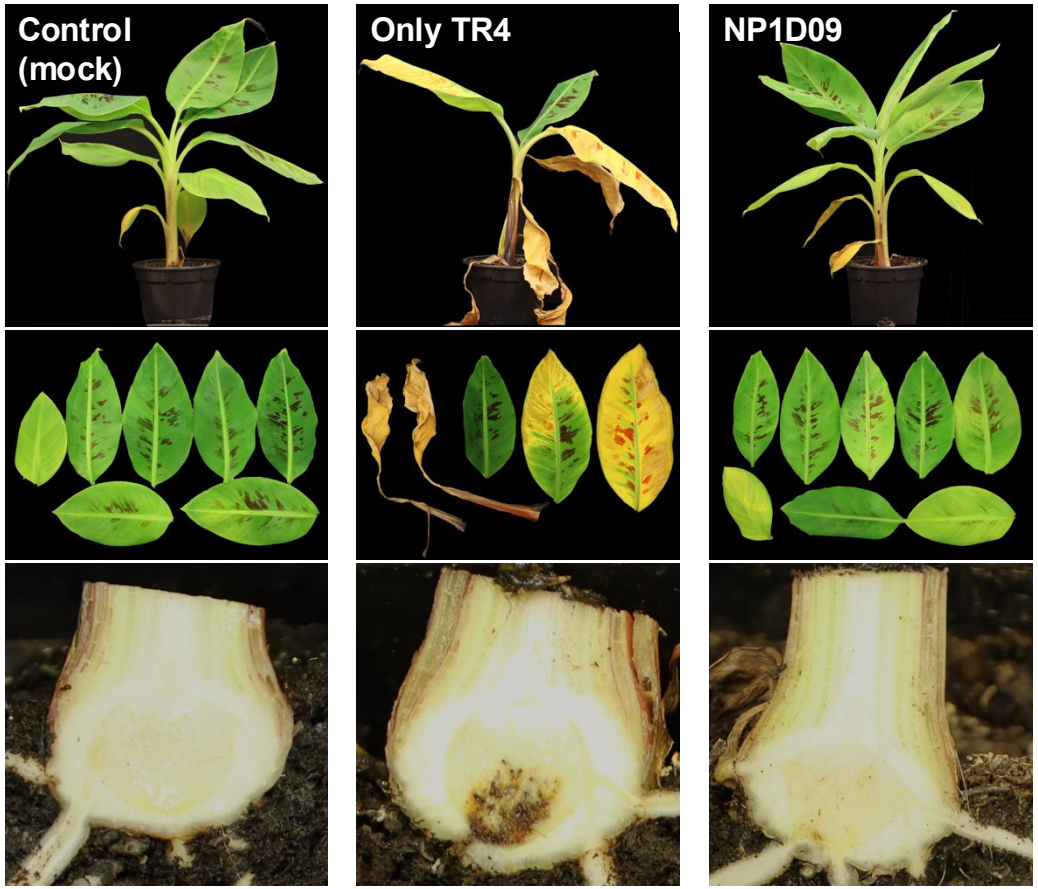
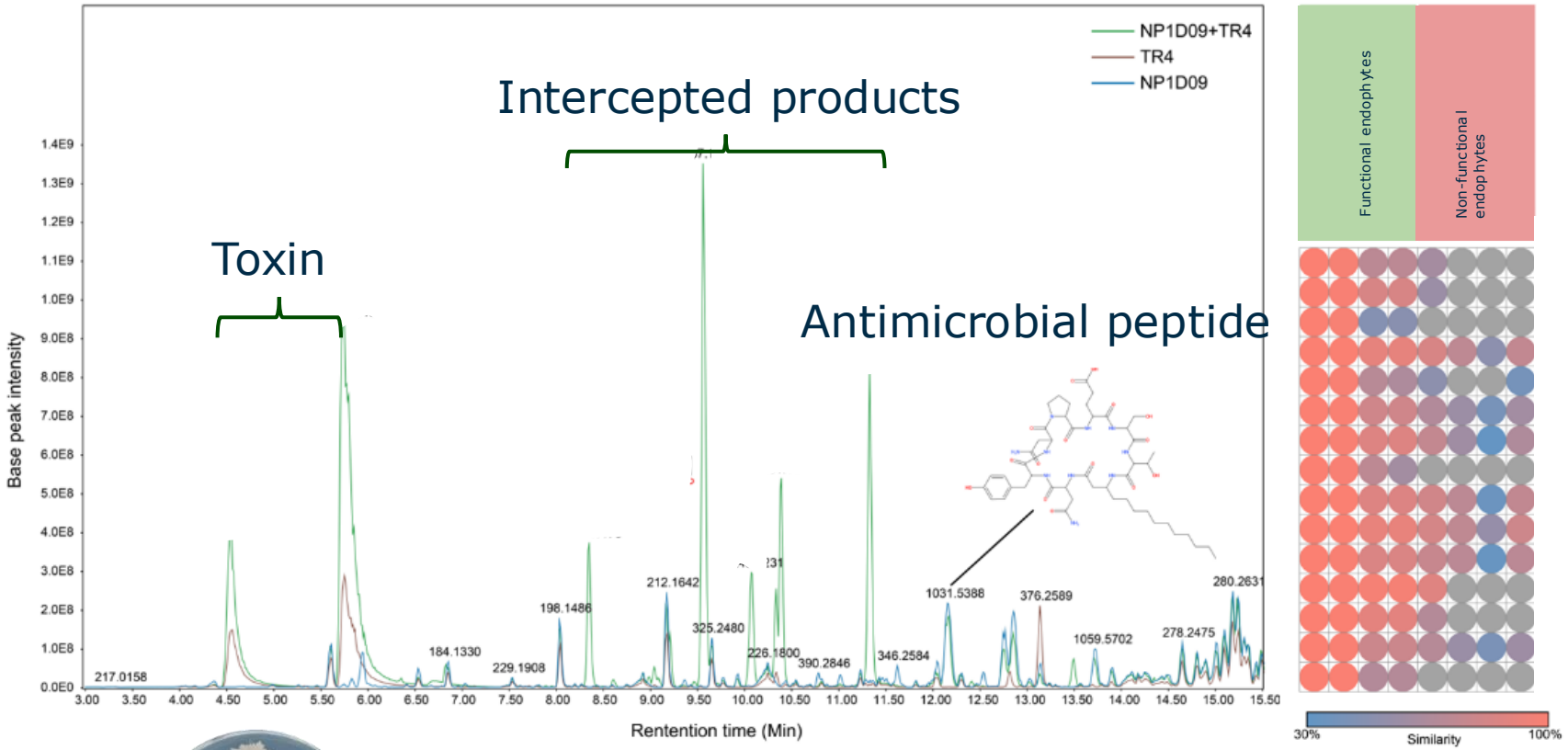
Functional strains repeatedly converge on similar antimicrobial architectures.

Functional endophytes suppress Fusarium in banana

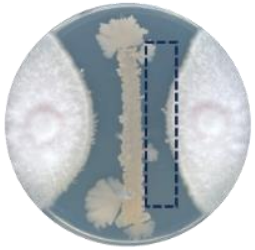
Endophyte



Functional endophytes suppress Fusarium through antimicrobial peptides and fungal toxin detoxification



Genes involved in toxin interception



Fusarium-Endophyte (NP1D09)

Endophyte (NP1D09)

Fusarium

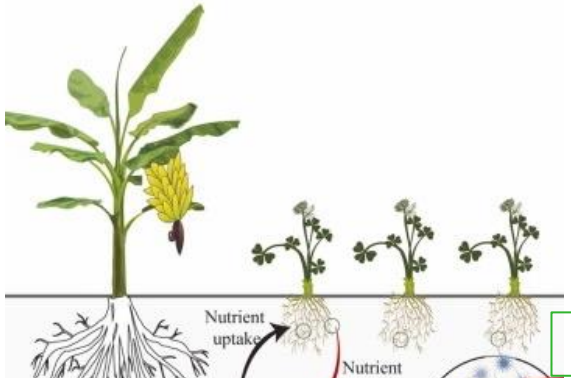
Protection is not a single mechanism. Functional endophytes survive pathogen chemistry while simultaneously inhibiting pathogen growth.

Partnership between plants to harness beneficial microbes

Luisa Pinna

Stijn van der Heijden

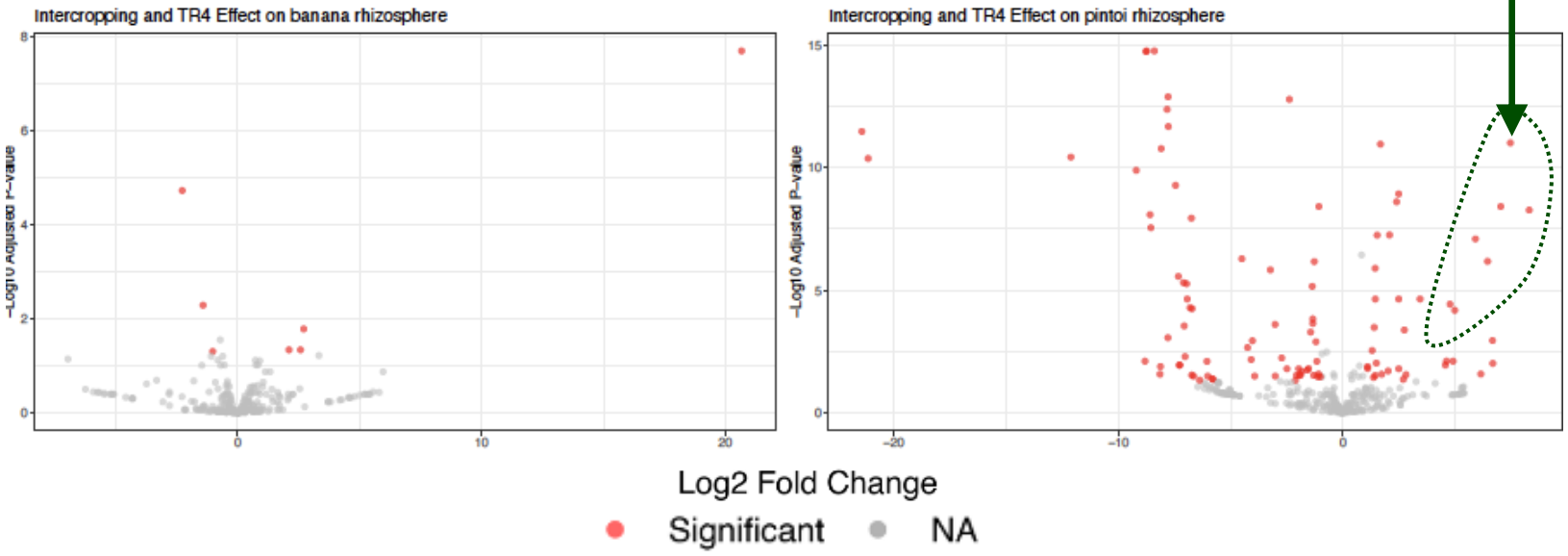
Sen Xi

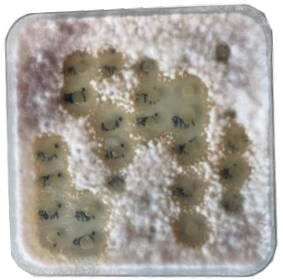


Banana rhizosphere

Cover crop rhizosphere

Bacteria with antifungal activity



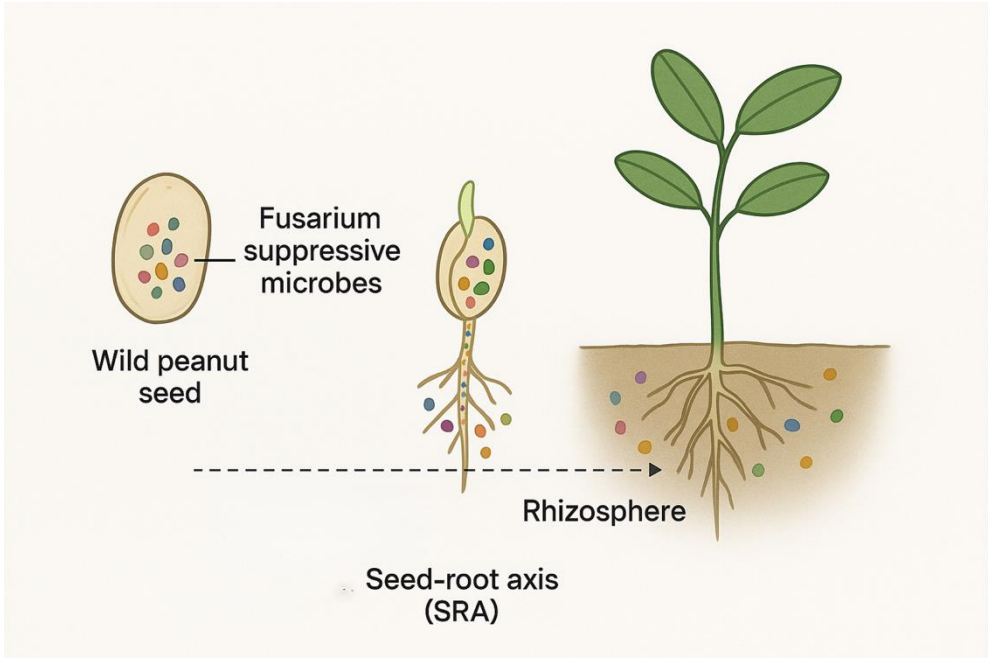


Disease resilience can emerge from plant–plant–microbiome partnerships.

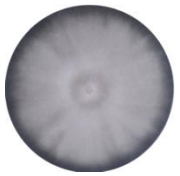
Pathogen suppressive microbial seed-root-axis

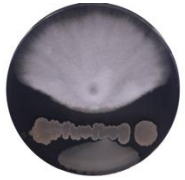
Weis Bos

Beneficial bacteria move from the seed to the root and protect plants from fungal infection.



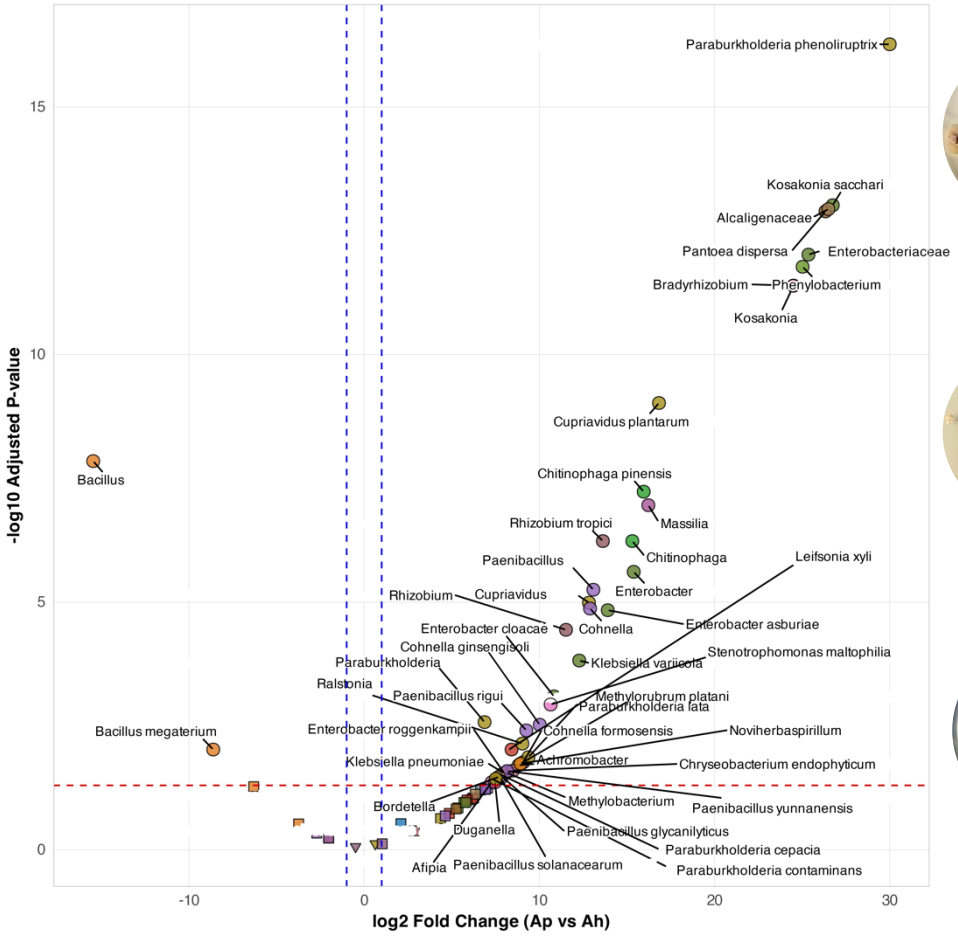
Luisa Pinna

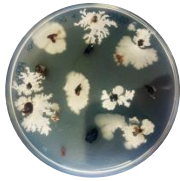




Cultivated peanut

Wild peanut





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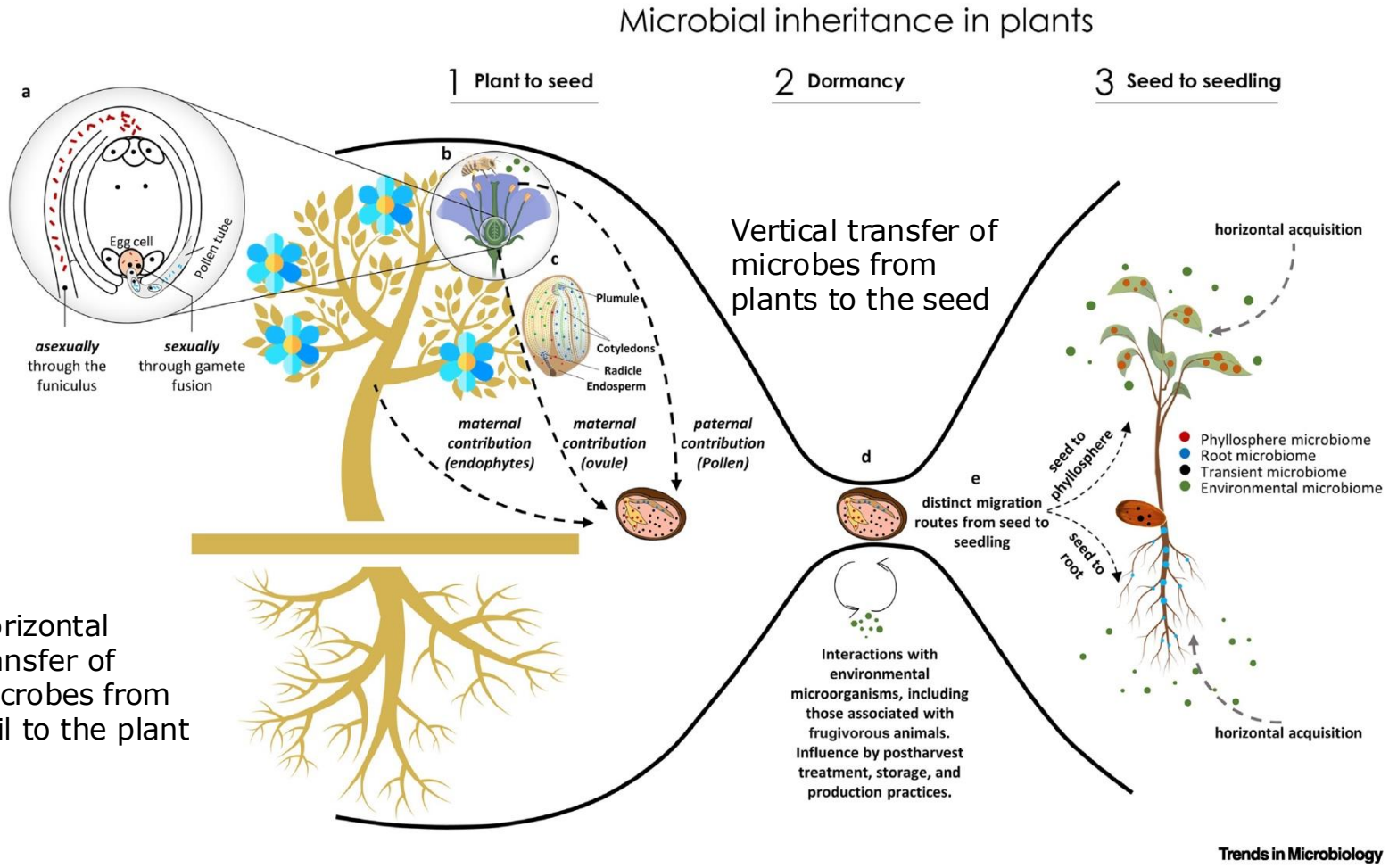
Wild peanut seeds harbor richer, more multifunctional microbiomes.

Packaging of microbes for the next generation: Seed microbiomes



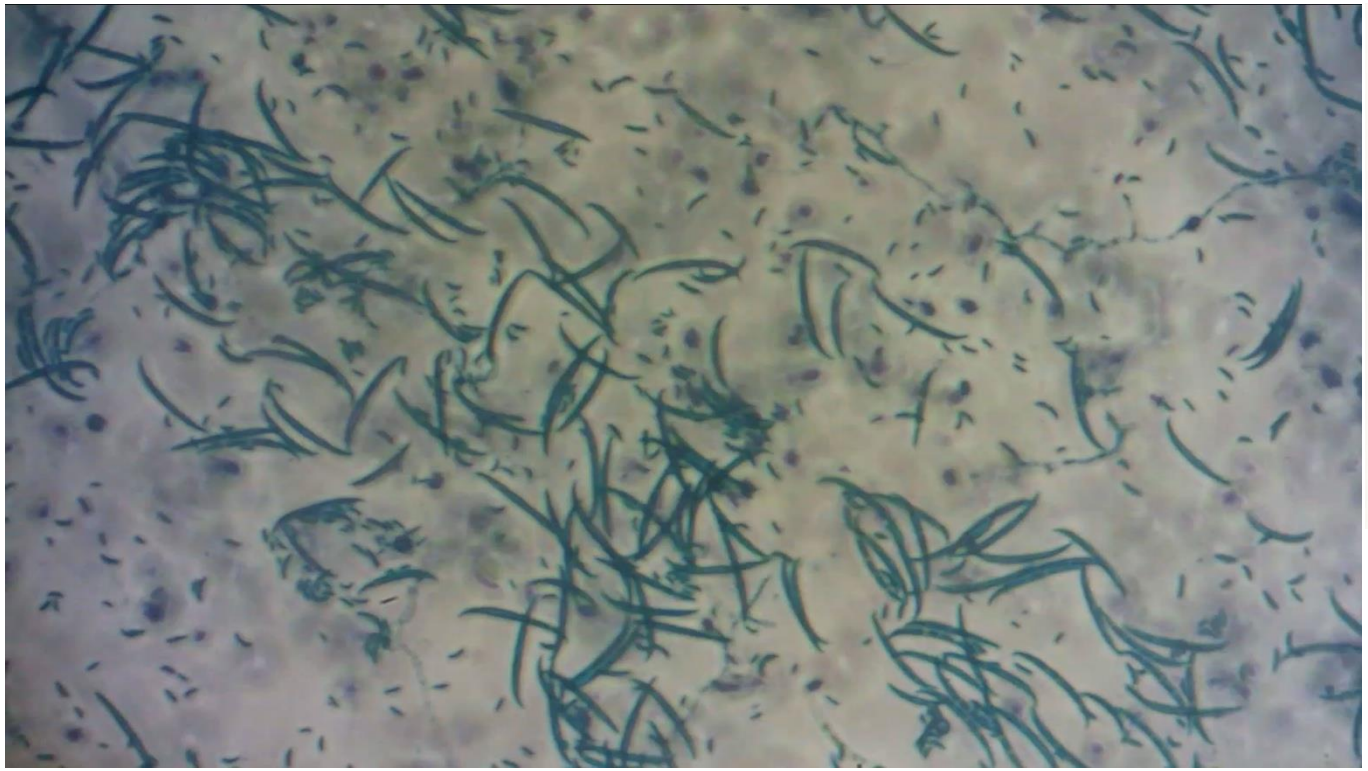
Vertical transfer of microbes from plants to the seed

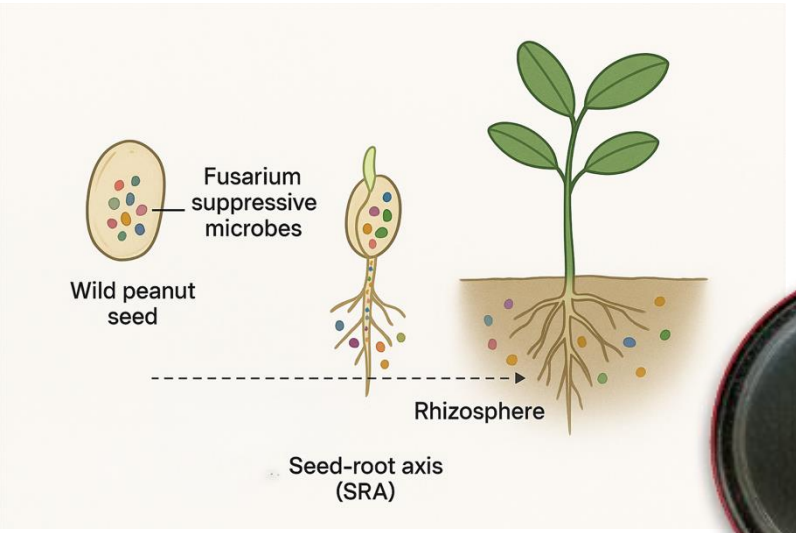
Horizontal transfer of microbes from soil to the plant

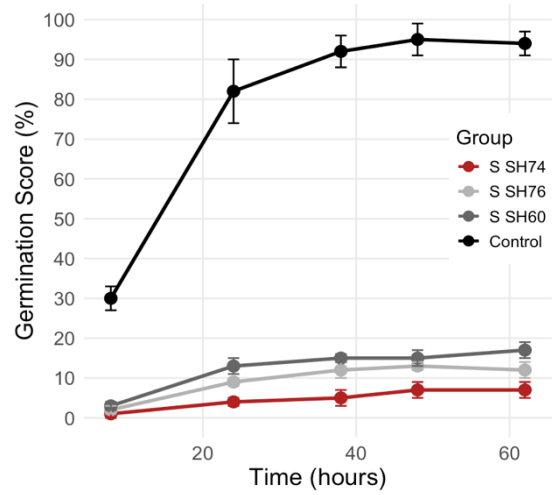
https://doi.org/10.1016/j.tim.2022.10.009

Microbiomes are also inherited, not just acquired.

Microbes as a tool to clean Fusarium propagules







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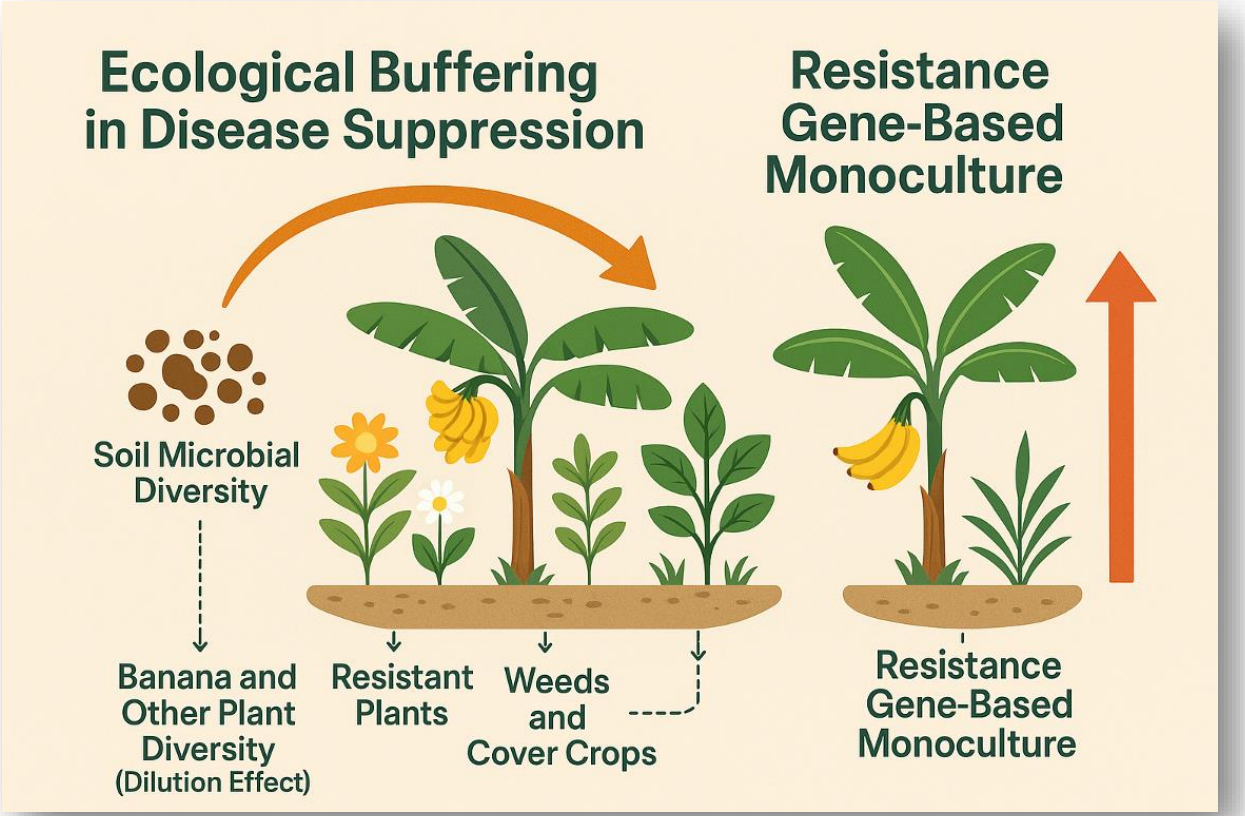
Wild peanut seed microbiota suppress Fusarium germination and mycelial growth.

From suppressive soils to a resilient cropping system



Selection pressure on pathogens

The future of disease resilience may therefore depend less on introducing external inputs and more on understanding how plants recruit, maintain, and pass protective microbiomes across generations.

Soil suppressiveness is an emergent ecological function shaped by microbial interactions, plant recruitment, and evolutionary inheritance.

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