

A microscopic view of soil organisms, showing numerous small, elongated, and curved structures, likely nematodes or similar soil fauna, against a light background. The organisms are densely packed and appear to be moving or interacting with each other.

Soil Pathogen Suppressiveness

Mechanisms, Evidence and Pathways to Resilience

May 28 2026 | Desalegn W. Etalo

The paradox in plant health

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

Healthy field (suppressive soils)

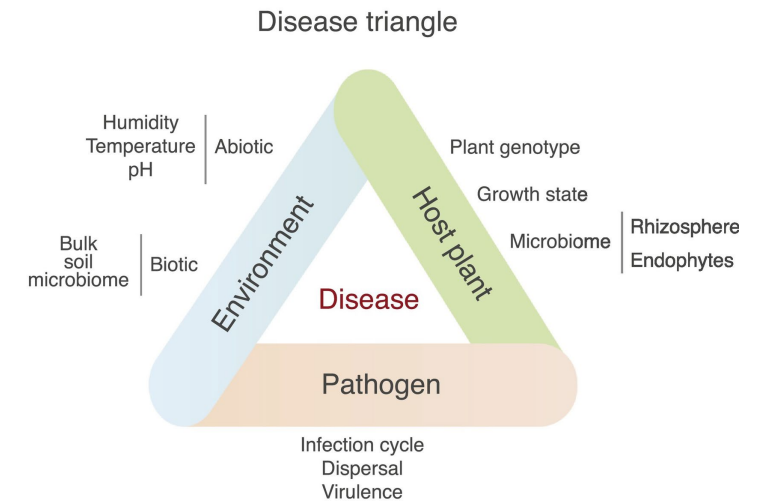


Limited symptoms and plants remain productive

Diseased field (conducive soils)

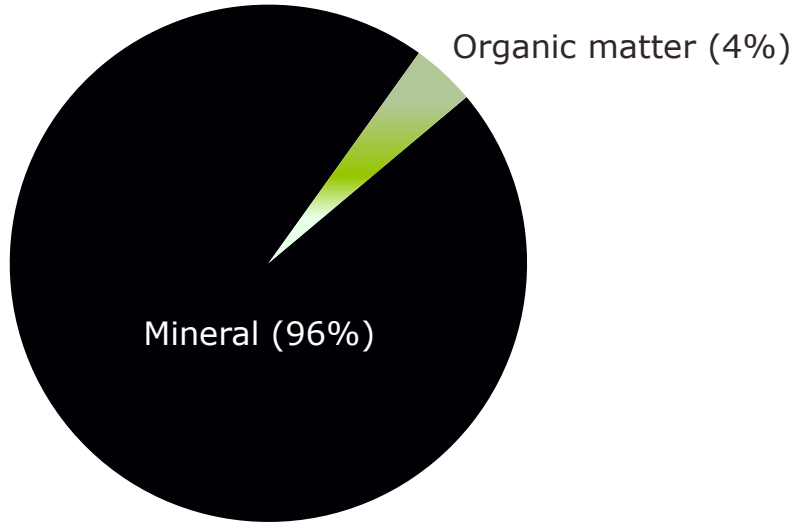


Severe disease and low productivity



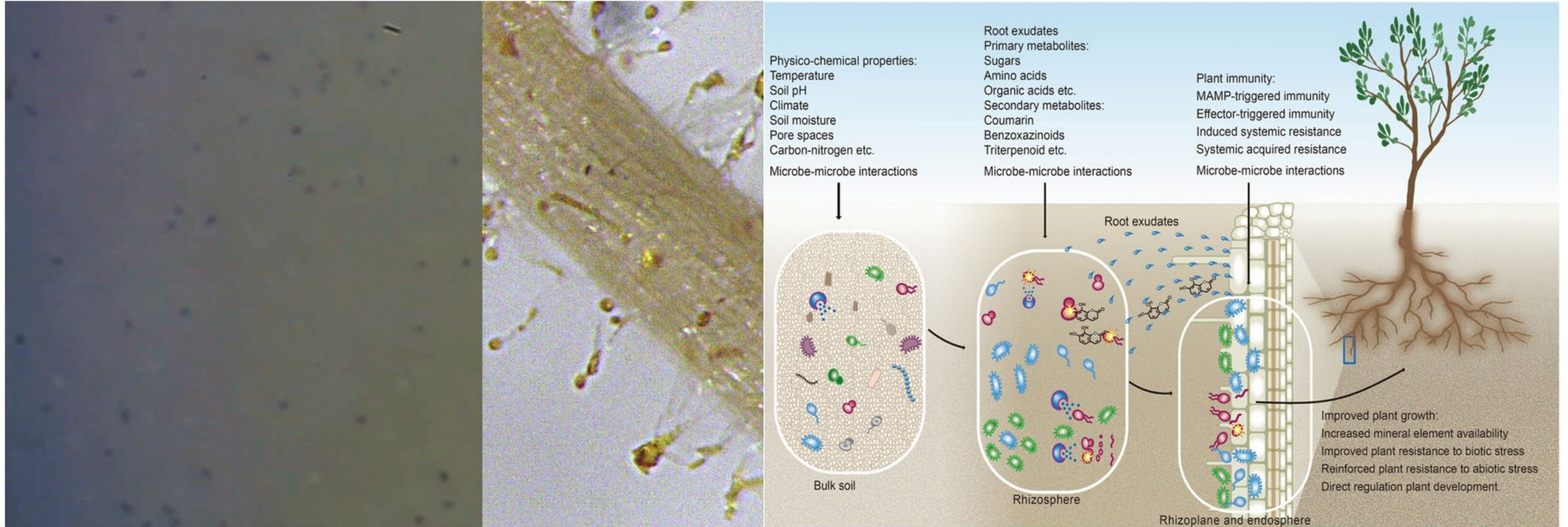
Soil: where it all starts

Soil

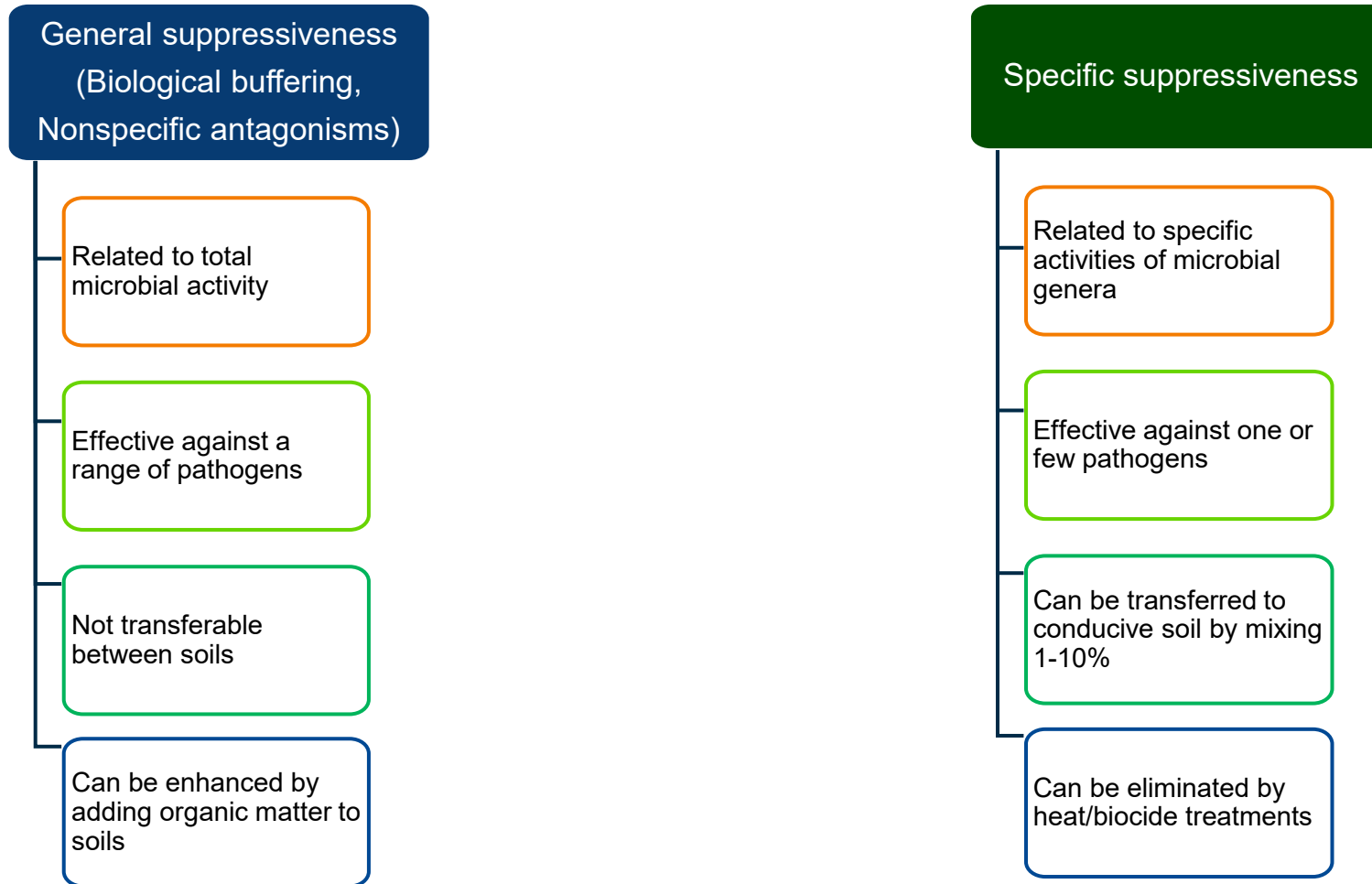


Microbiome assembly

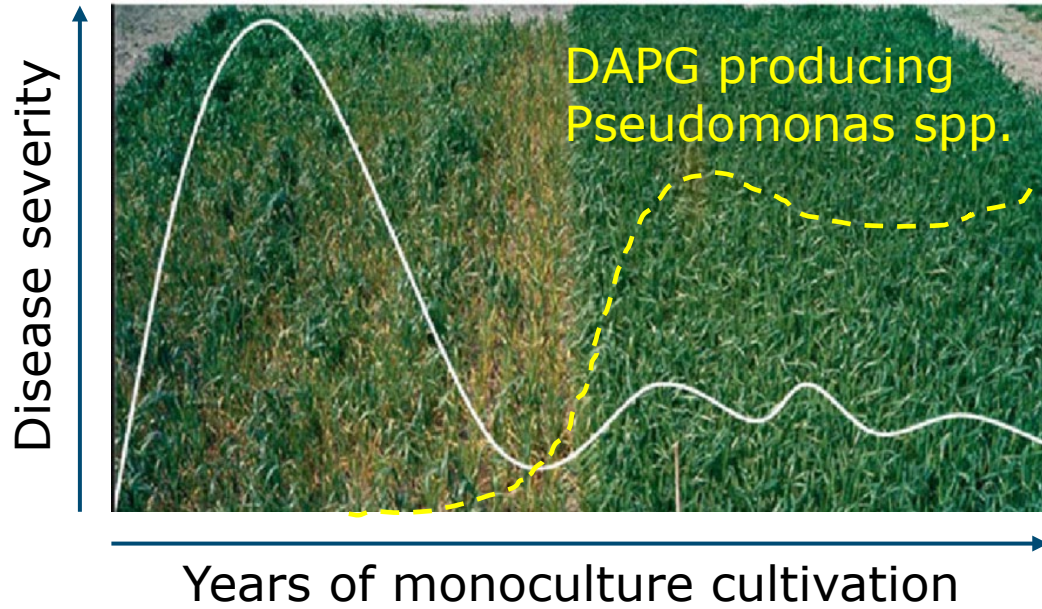
Attraction and assimilation



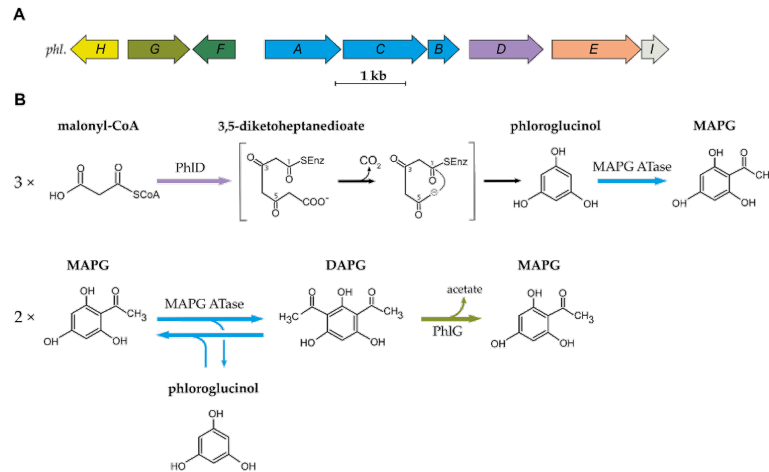
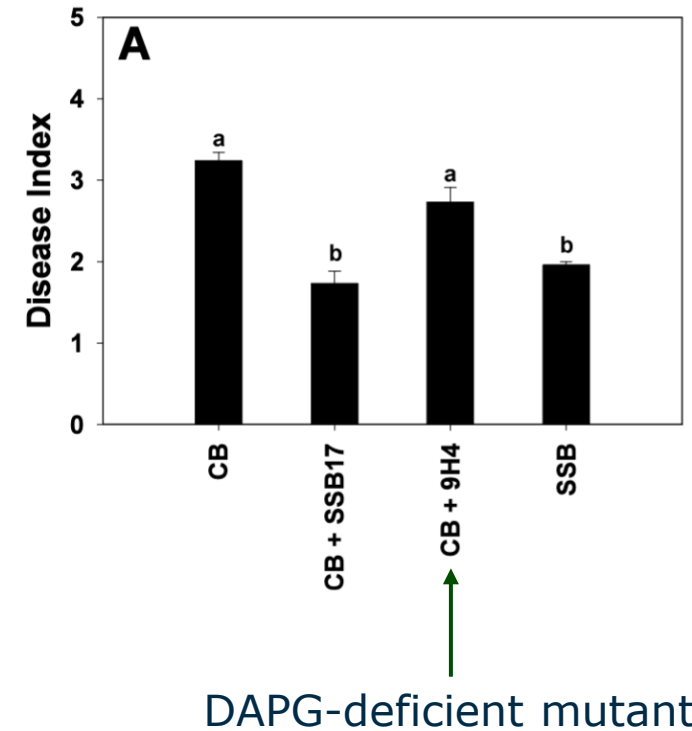
Two types of soil suppressiveness to pathogens



Take-all-decline (TAD)-Specific suppression

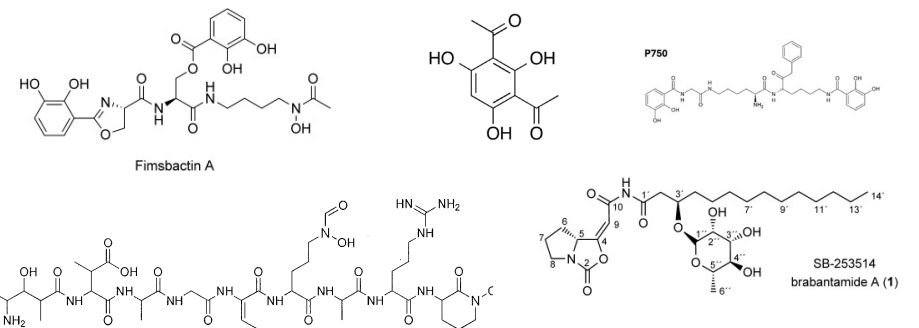
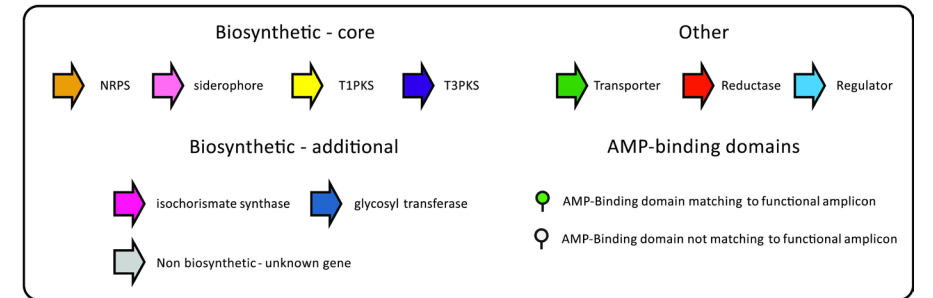
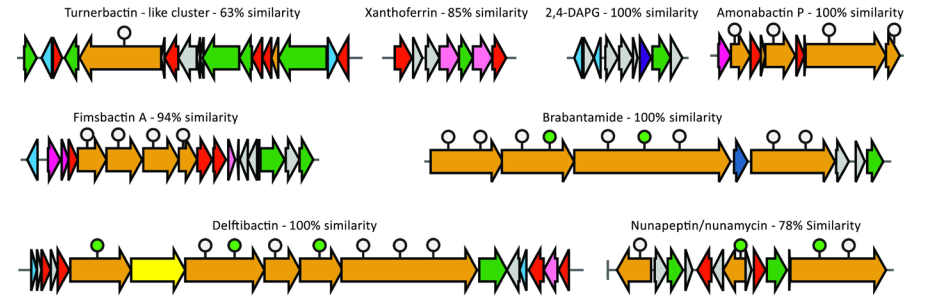
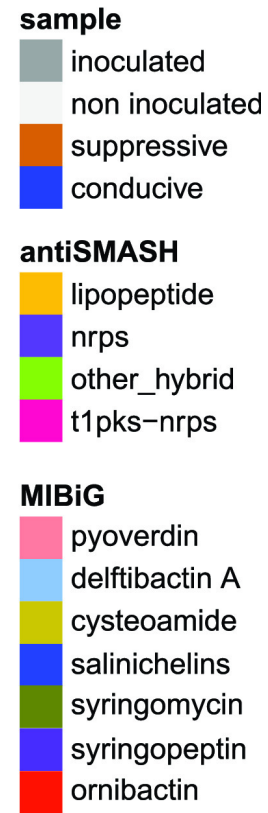
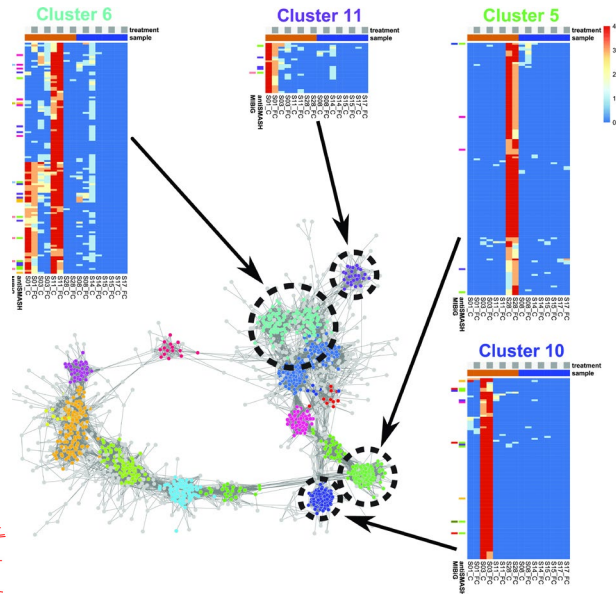
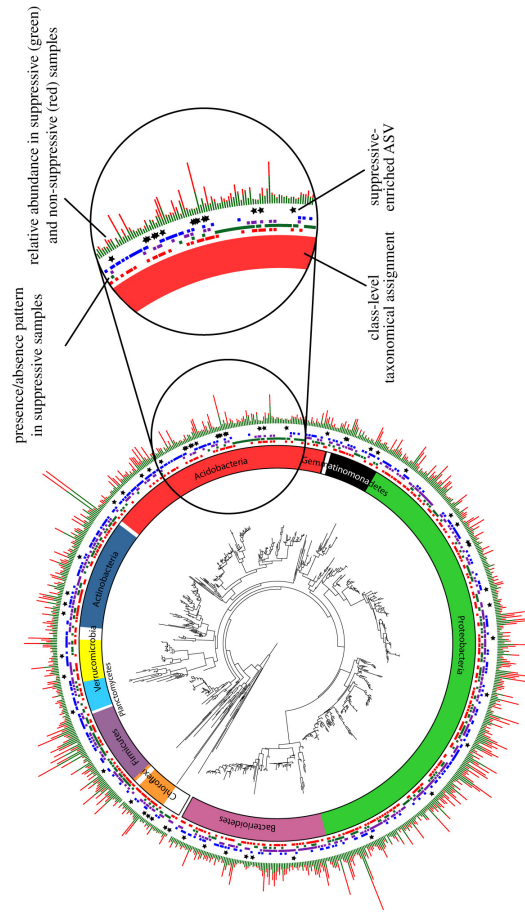


de Souza et al. 2003



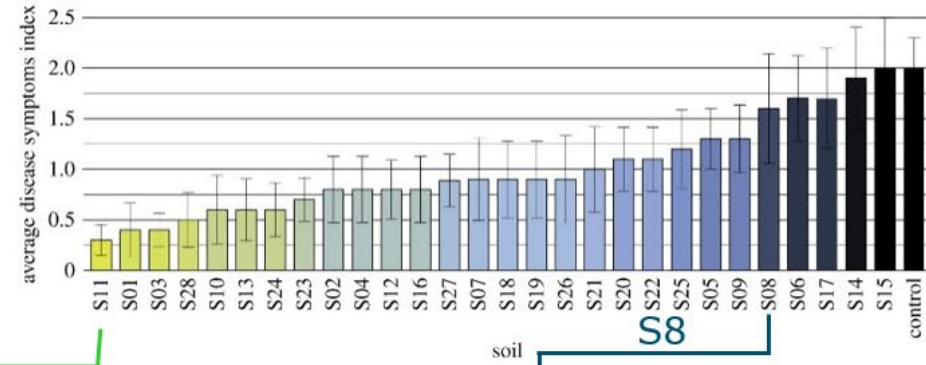
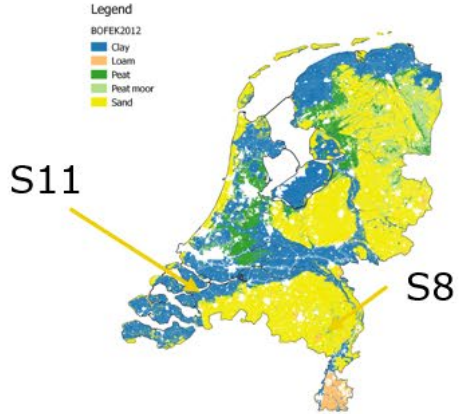
Caused by *Gaeumannomyces tritici*

Disease suppressive functions in soil-metagenome

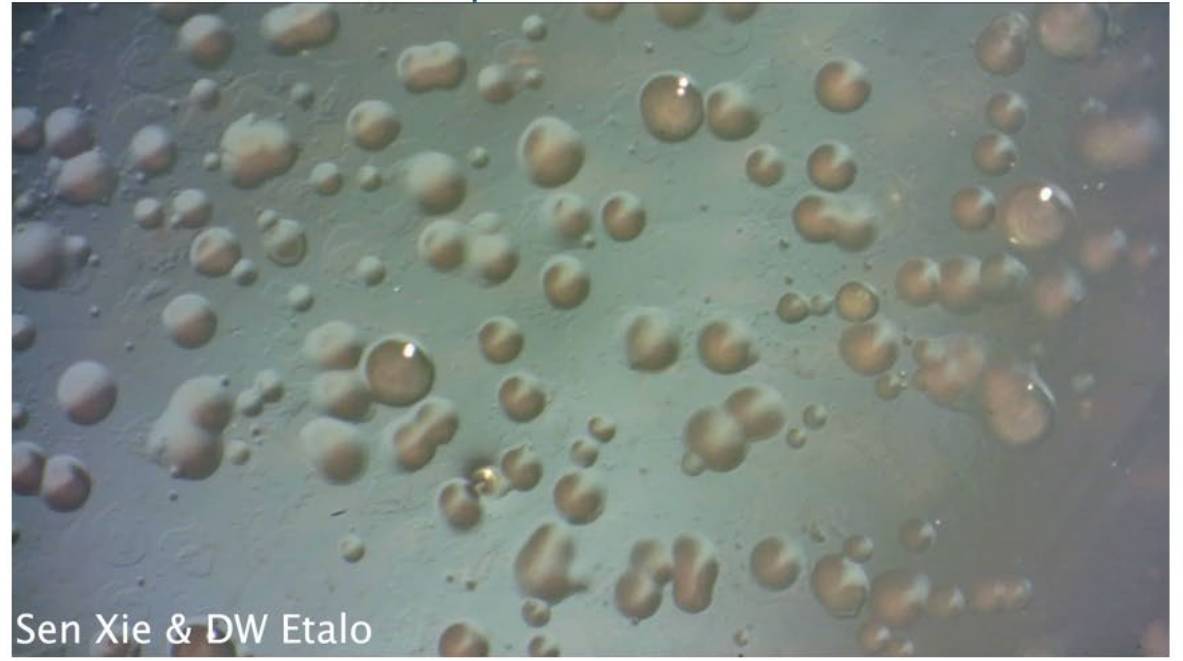
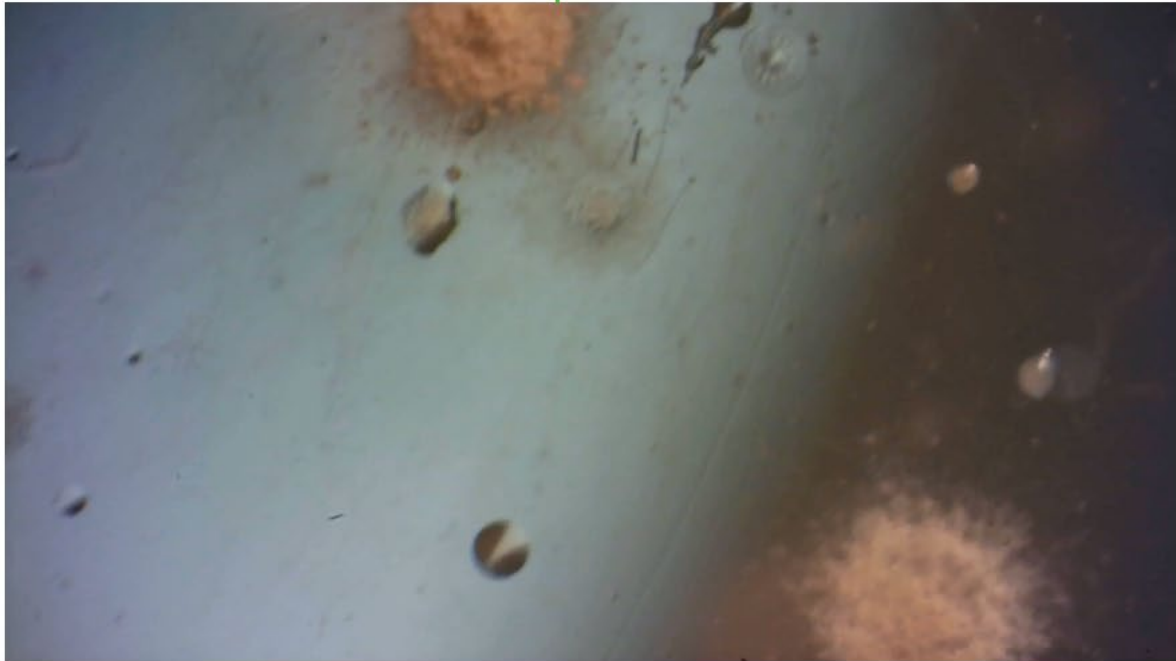


<https://doi.org/10.1128/mSystems.01116-20>

Culturomics to unravel disease suppressive agents



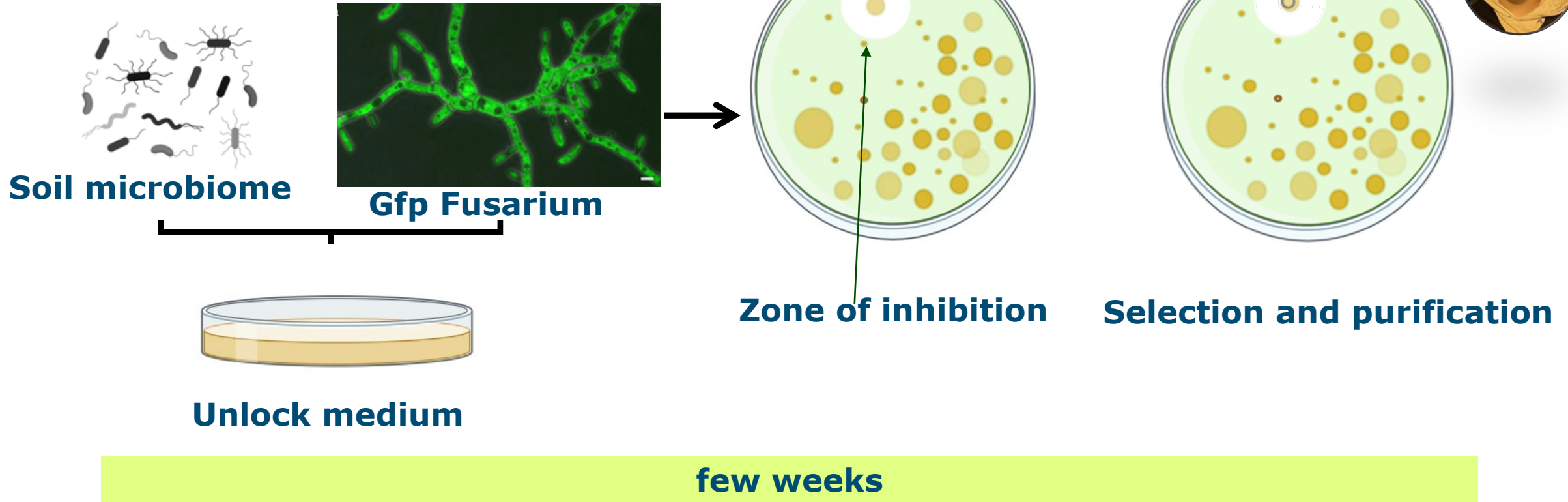
Ossowick et al., 2020



S11

S8

From soil microbiome to functional antagonist

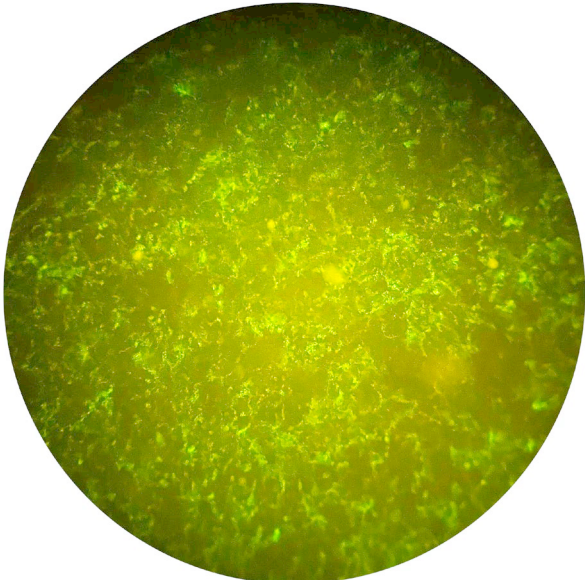


***Unlock Medium (UM): Media mimicking the rhizosphere environment**

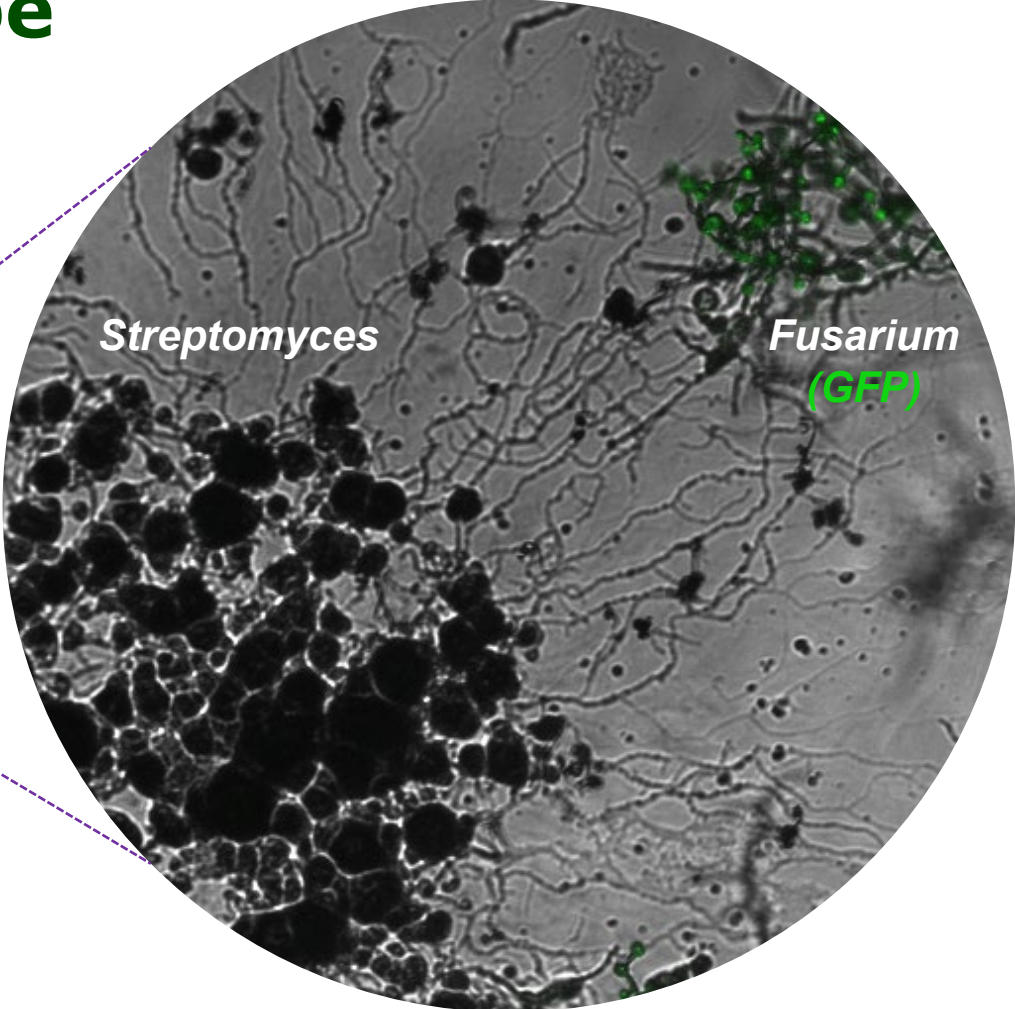
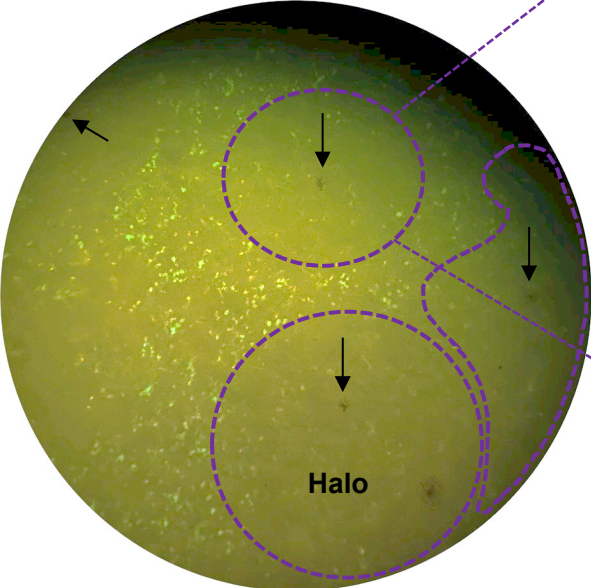
Function-guided culturomics to isolate disease suppressive microbe



S08 (Conducive soil)



S11 (Suppressive soil)



Co-cultivation of soil microbiome and Fusarium

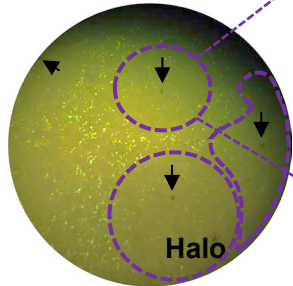
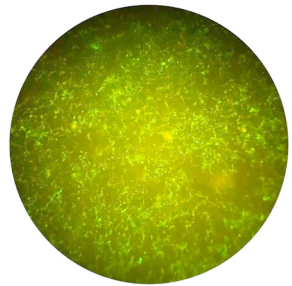
Confocal microscopy

Actinomycetes antagonistic phylogenetic signal

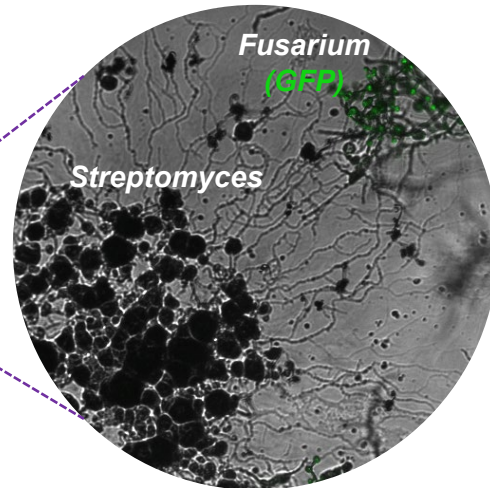
■ **Suppressive Soil**
 ■ **Conductive soil**

S08 (Conductive soil)

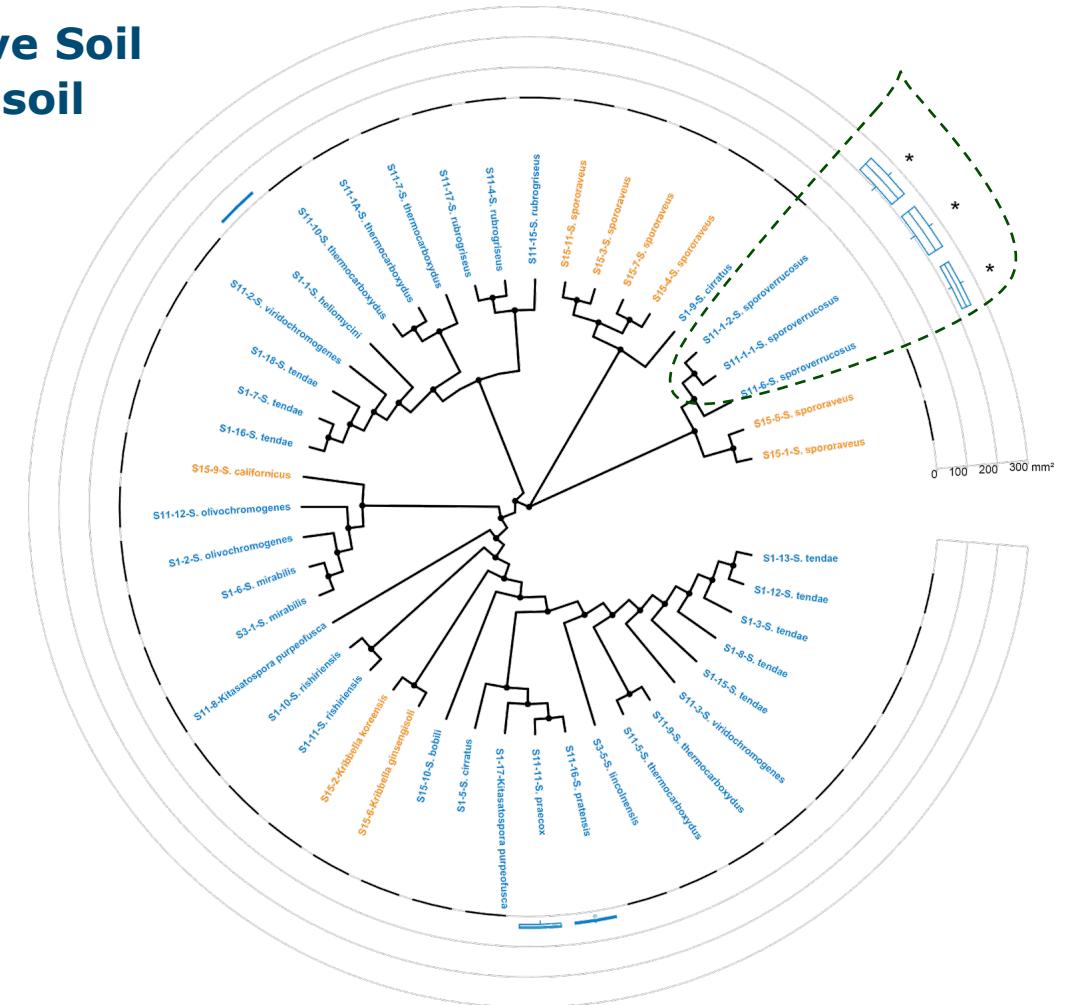
S11 (Suppressive soil)



Co-cultivation of soil microbiome and *Fusarium*



Confocal microscopy



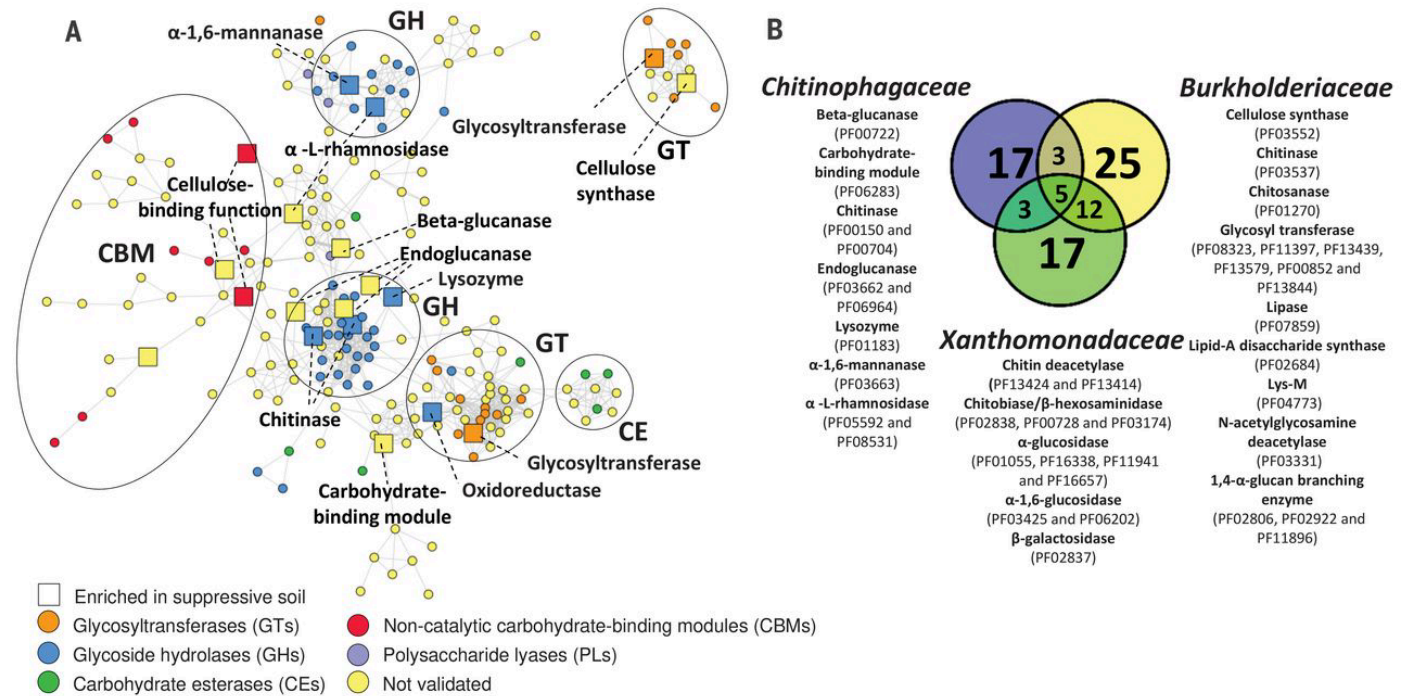
Fusarium suppression

Suppressive soils reshape the internal plant microbiome



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

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



Science

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RESEARCH ARTICLE

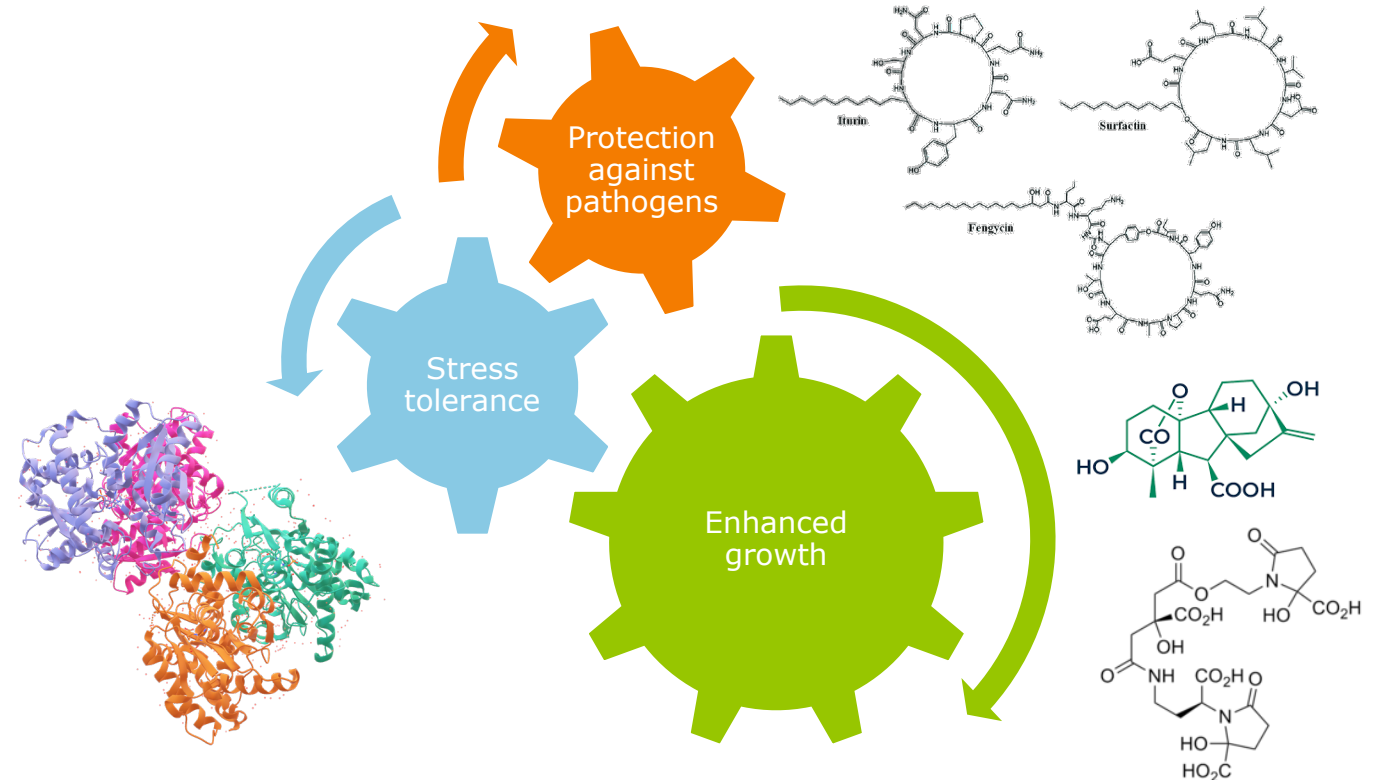
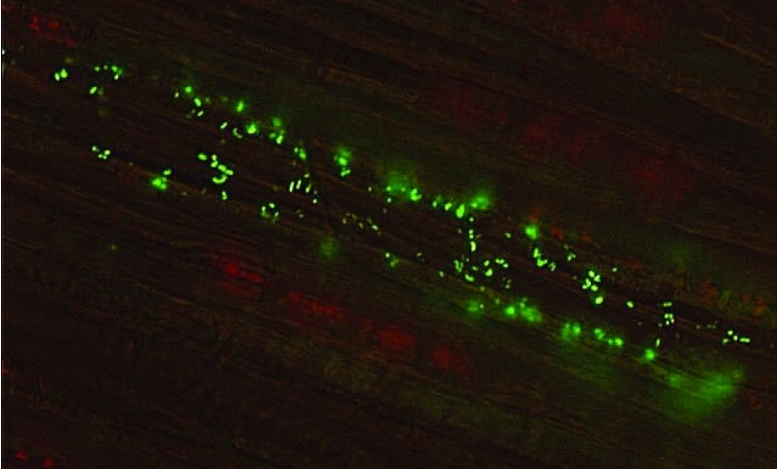
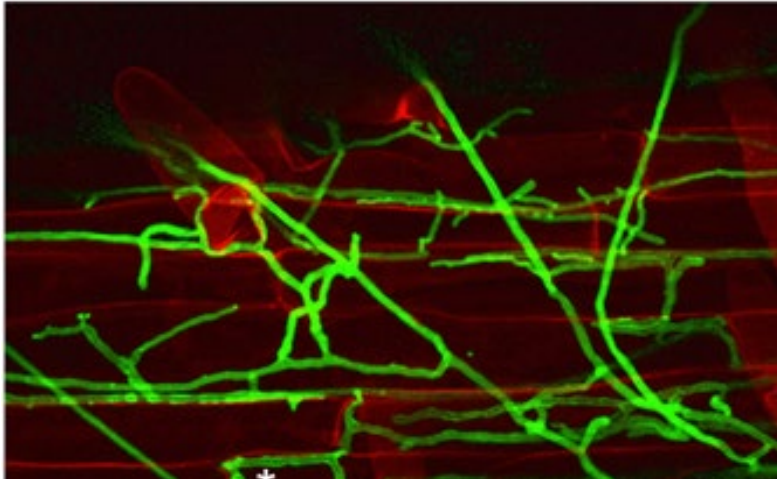
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Pathogen-induced activation of disease-suppressive functions in the endophytic root microbiome

VICTOR J. CARRIÓN, JUAN PEREZ-JARAMILLO, VIVIANE CORDOVEZ, VITTORIO TRACANNA, MATTIAS DE HOLLANDER, DANIEL RUIZ-BUCK, LUCAS W. MENDES, WILFRED F.J. VAN LUCKEN, RUTH GOMEZ-EXPOSITO, [...] AND JOS M. RAALUMAKERS +8 authors Authors Info & Affiliations

Harnessing endophytes for pathogen suppression

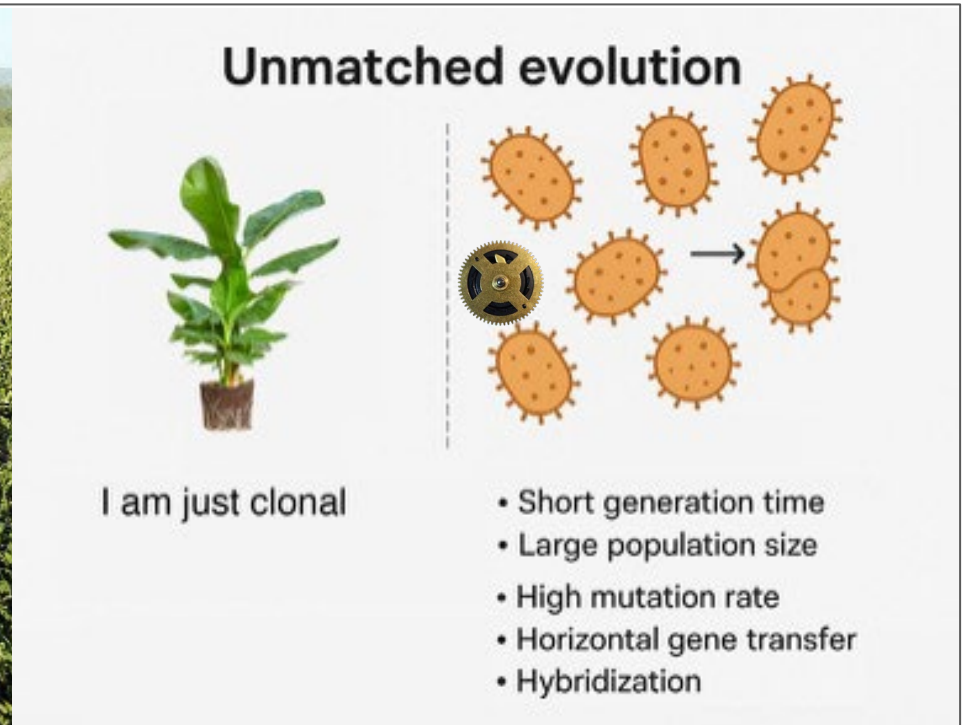
- Endophytes are microorganisms, such as bacteria or fungi, that live inside plant tissues without causing apparent harm.



Endophytes as a plant ally to counter fast evolving pathogen

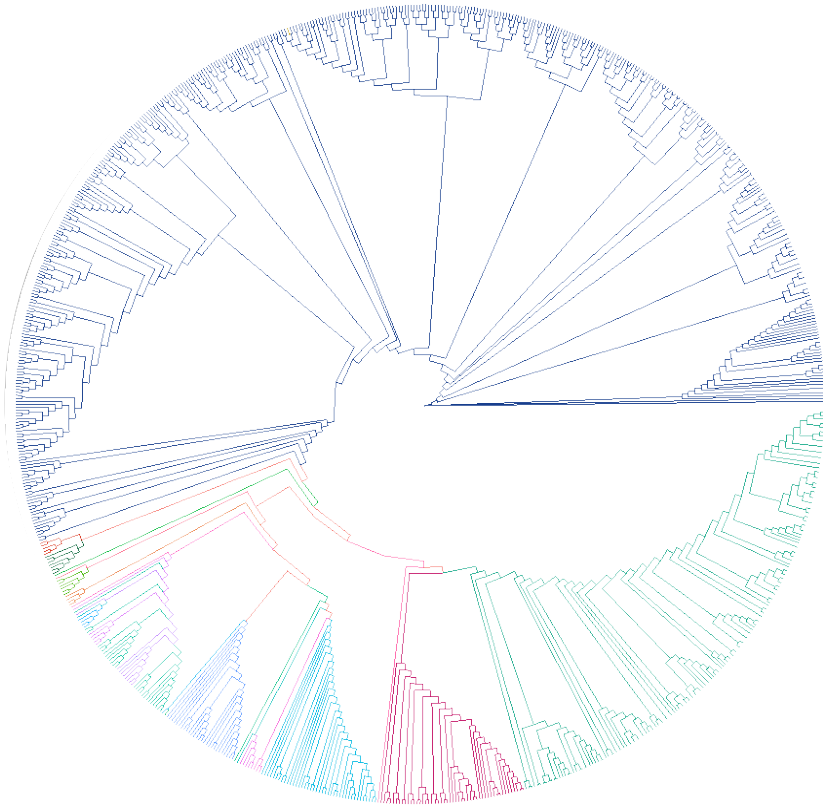


Convenience and consumers' demand



Sexual and clonal

Diverse endophyte collections to study disease suppressive functions

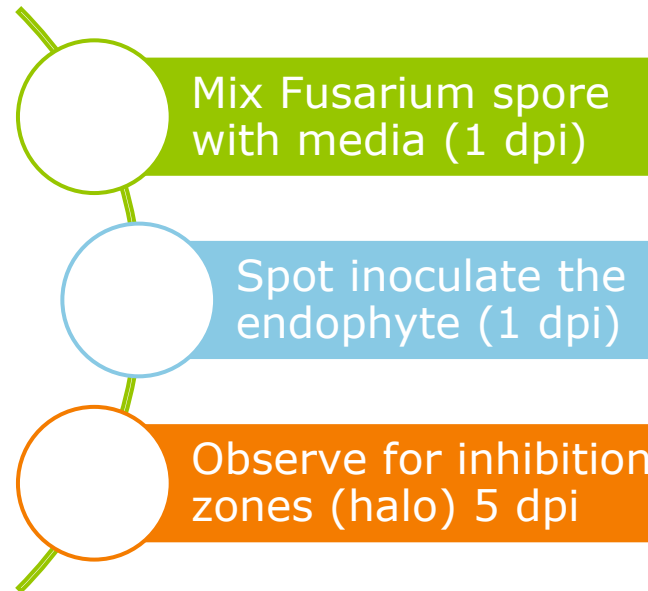
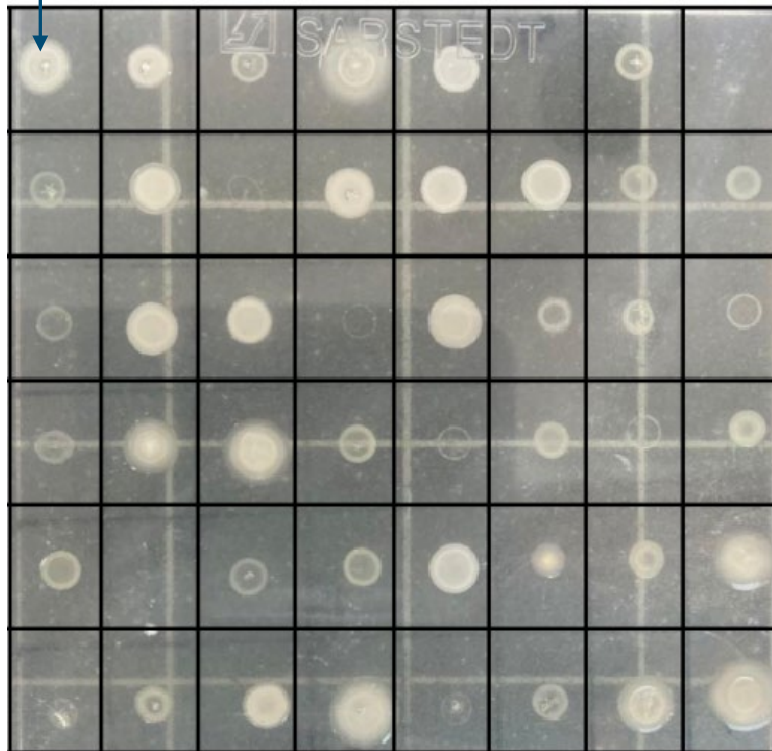


Over 1,300 endophytic isolates were collected from wild and domesticated banana and Enset plants. How can we evaluate their antagonistic potential against major banana pathogens?

High-throughput screening for pathogen suppression

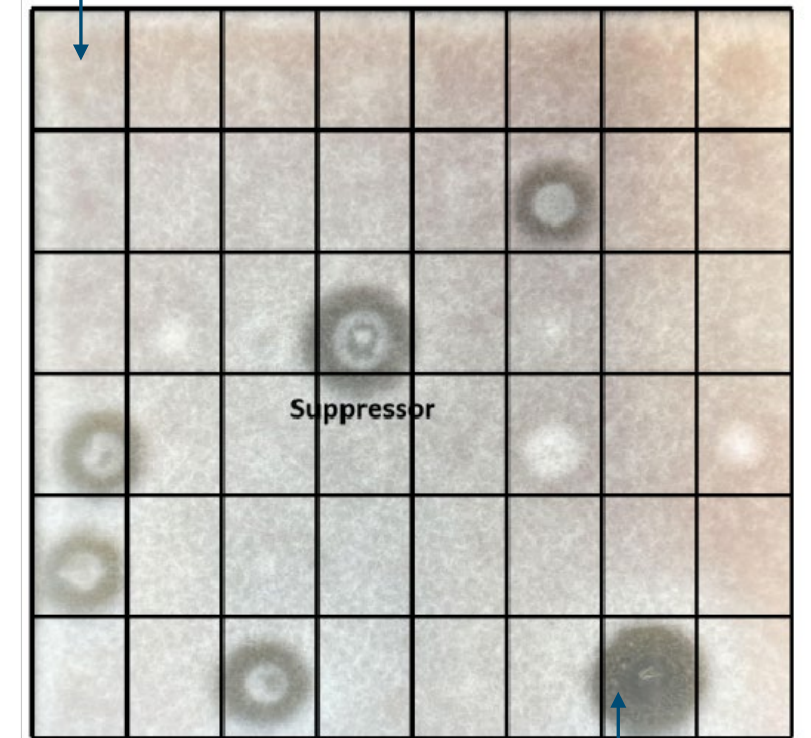
Endophyte spot inoculation

1 dpi



Fusarium

5 dpi

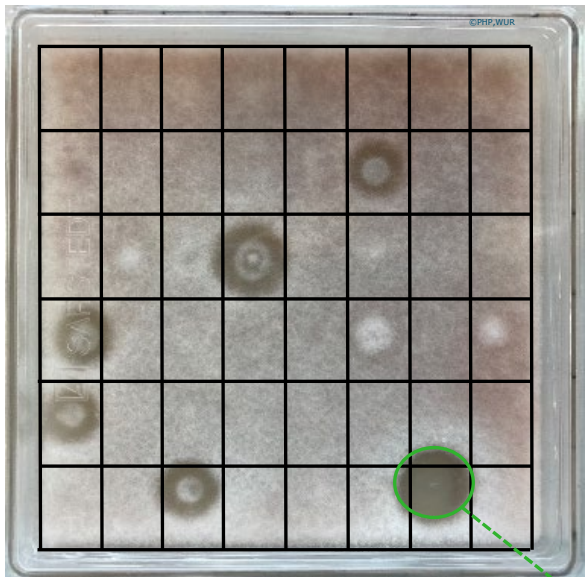


halo

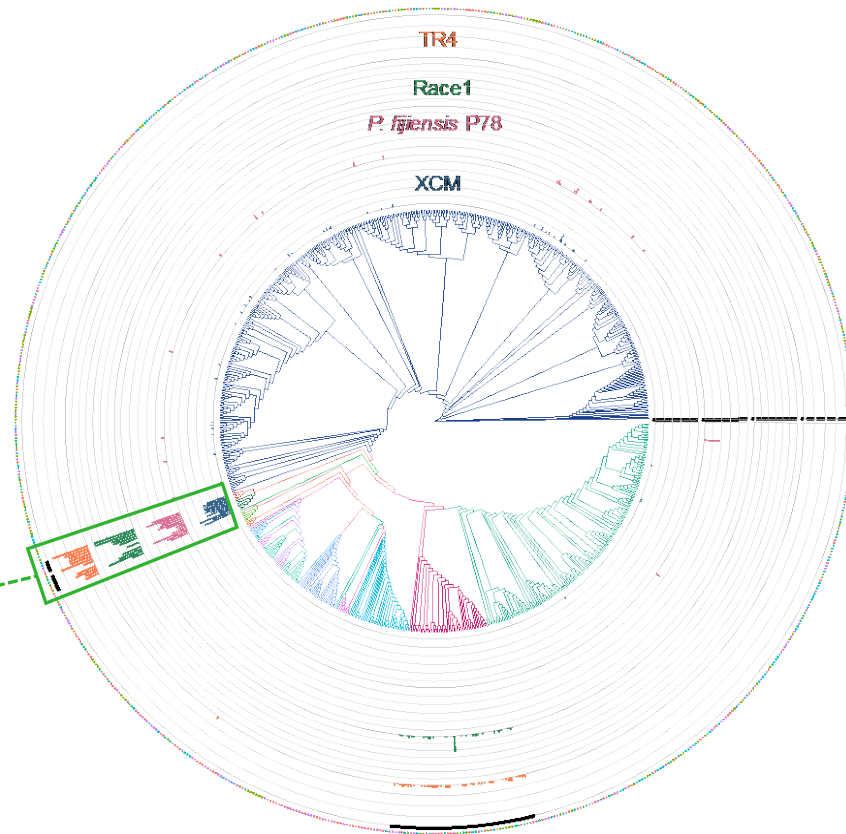
Endophytic cross-kingdom antagonistic signal



Fusarium (TR4)



Strong cross-kingdom antagonistic signal



P. fijiensis

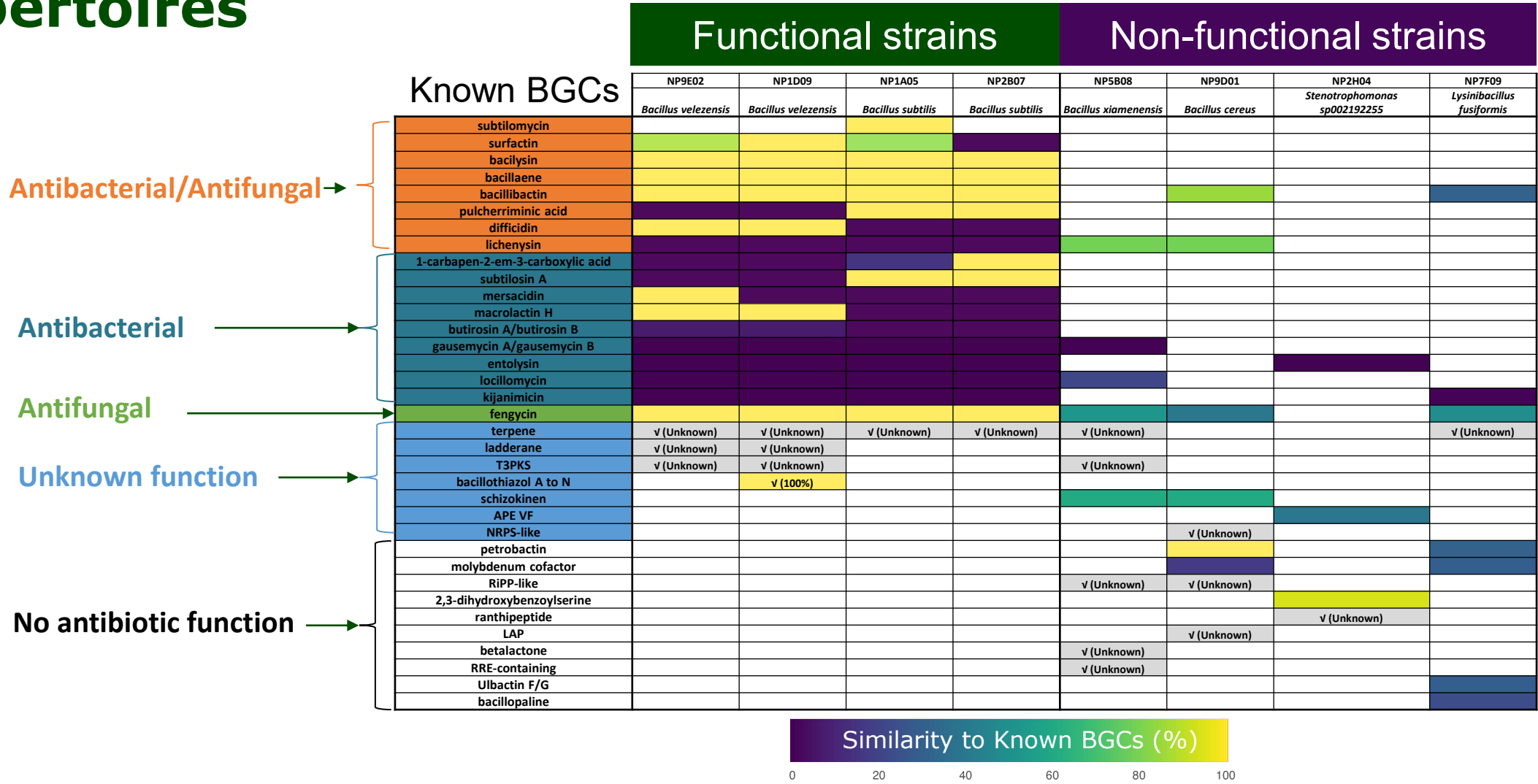


Xanthomonas campestris
(Xcm)



Banana pathogens

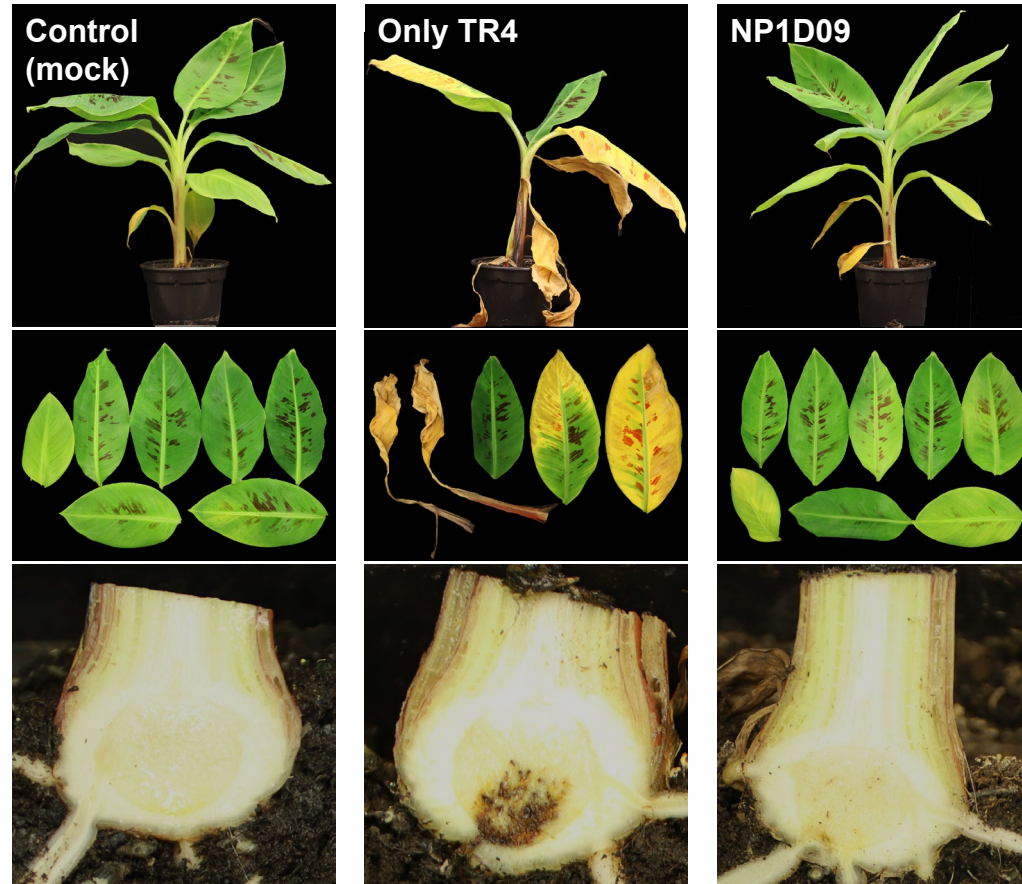
Functional endophytes share conserved antimicrobial repertoires



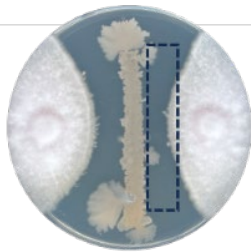
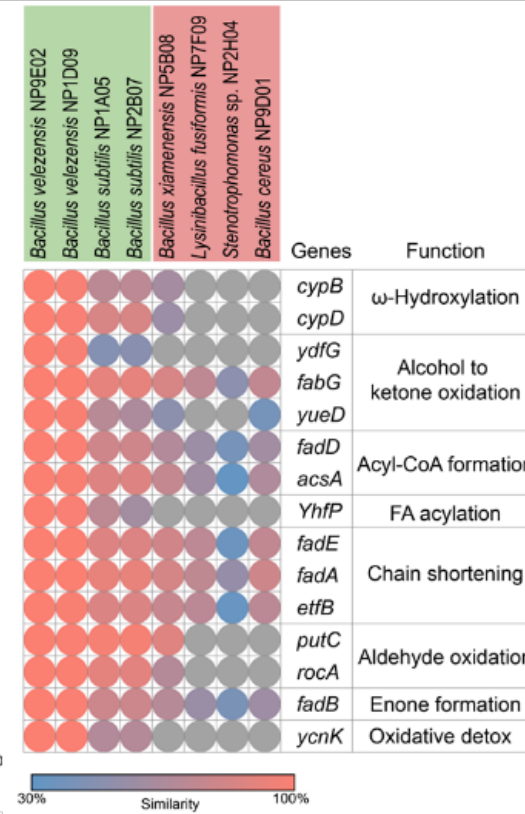
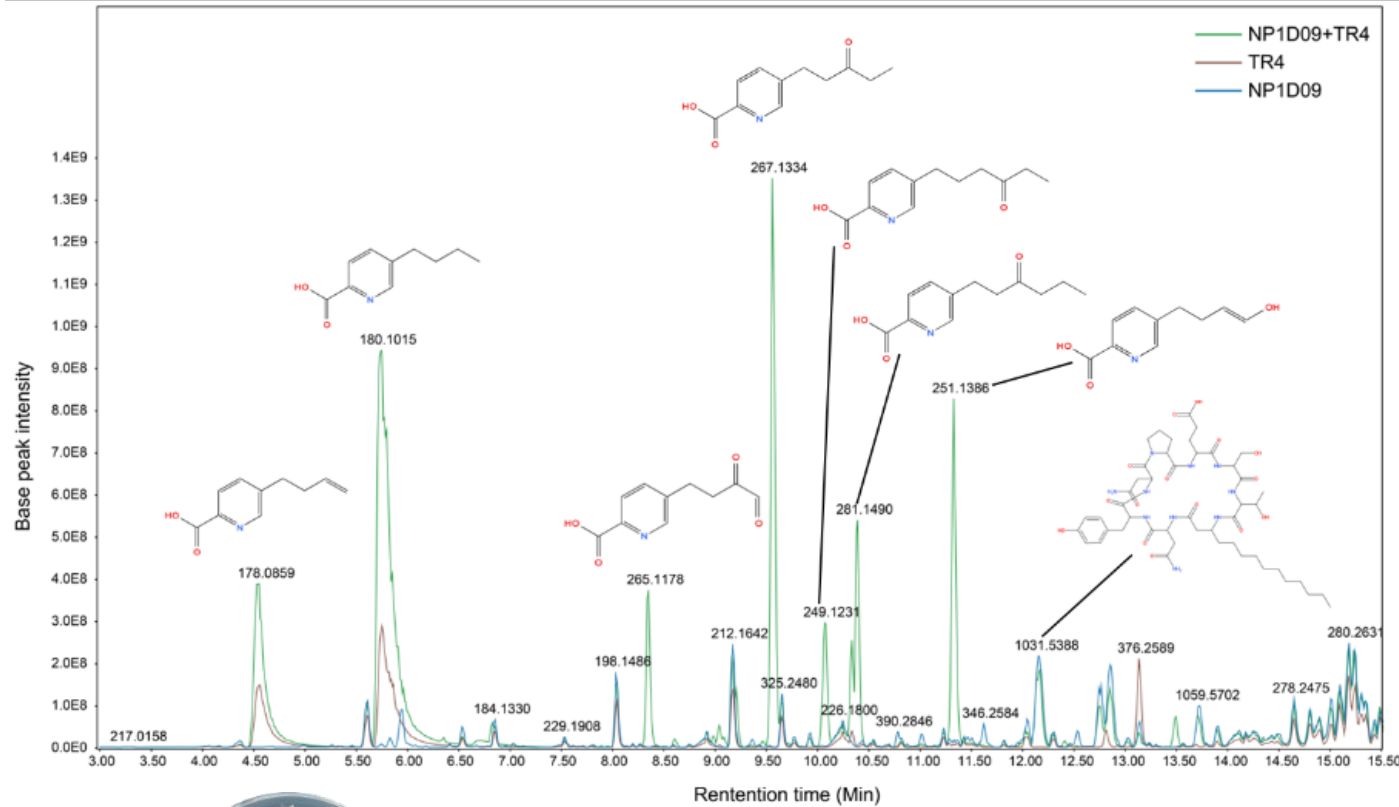
Functional endophytes suppress *Fusarium* in banana



Endophyte



Functional endophytes suppress *Fusarium* through antimicrobial peptides and fusaric acid detoxification



- Fusarium-Endophyte (NP1D09)
- Endophyte (NP1D09)
- Fusarium

Partnership between plants to harness beneficial microbes



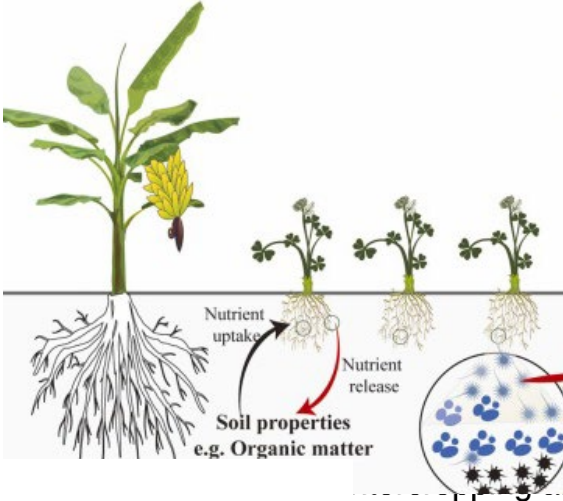
Luisa Pinna



Stijn van der Heijden

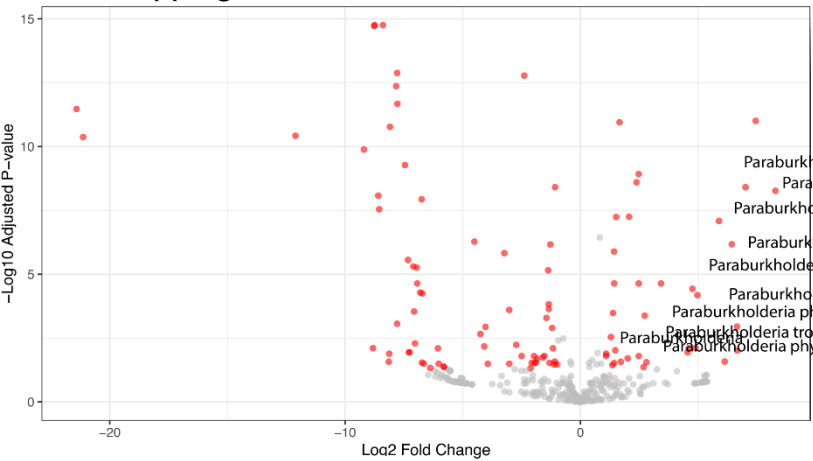
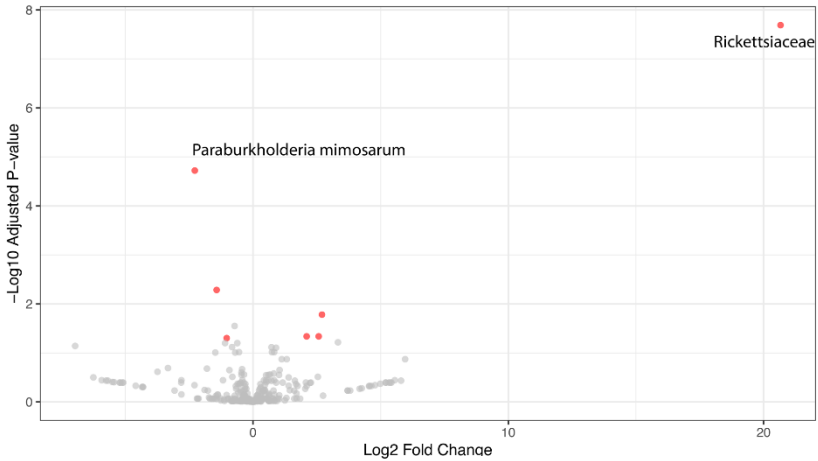


Sen Xi



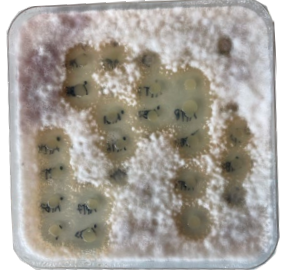
Banana rhizosphere

Cover crop rhizosphere



significant ● Not Significant ● Significant ● NA

Bacteria with antifungal activity

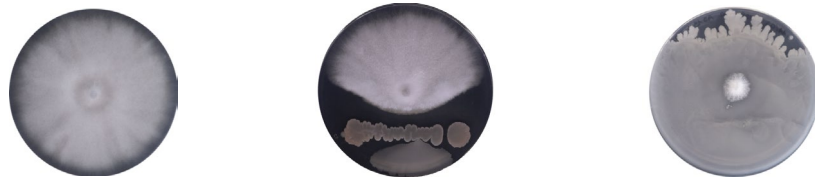
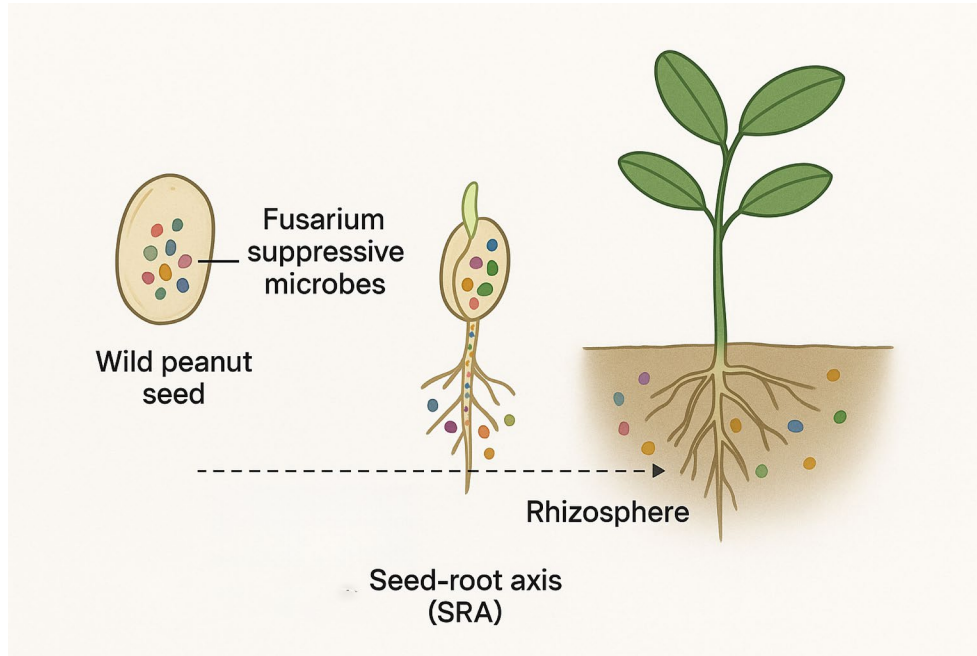


Pathogen suppressive microbial seed-root-axis



Weis Bos

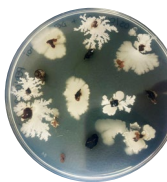
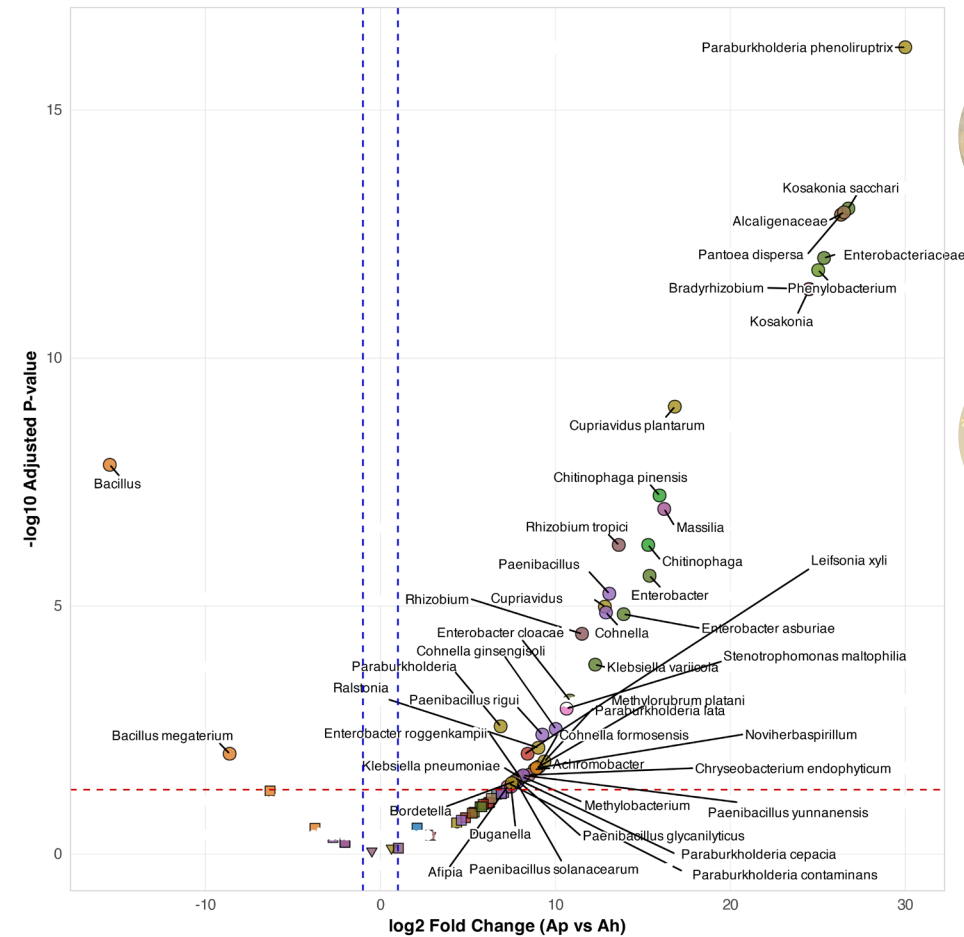
Beneficial bacteria move from the seed to the root and protect plants from fungal infection.



Luisa Pinna

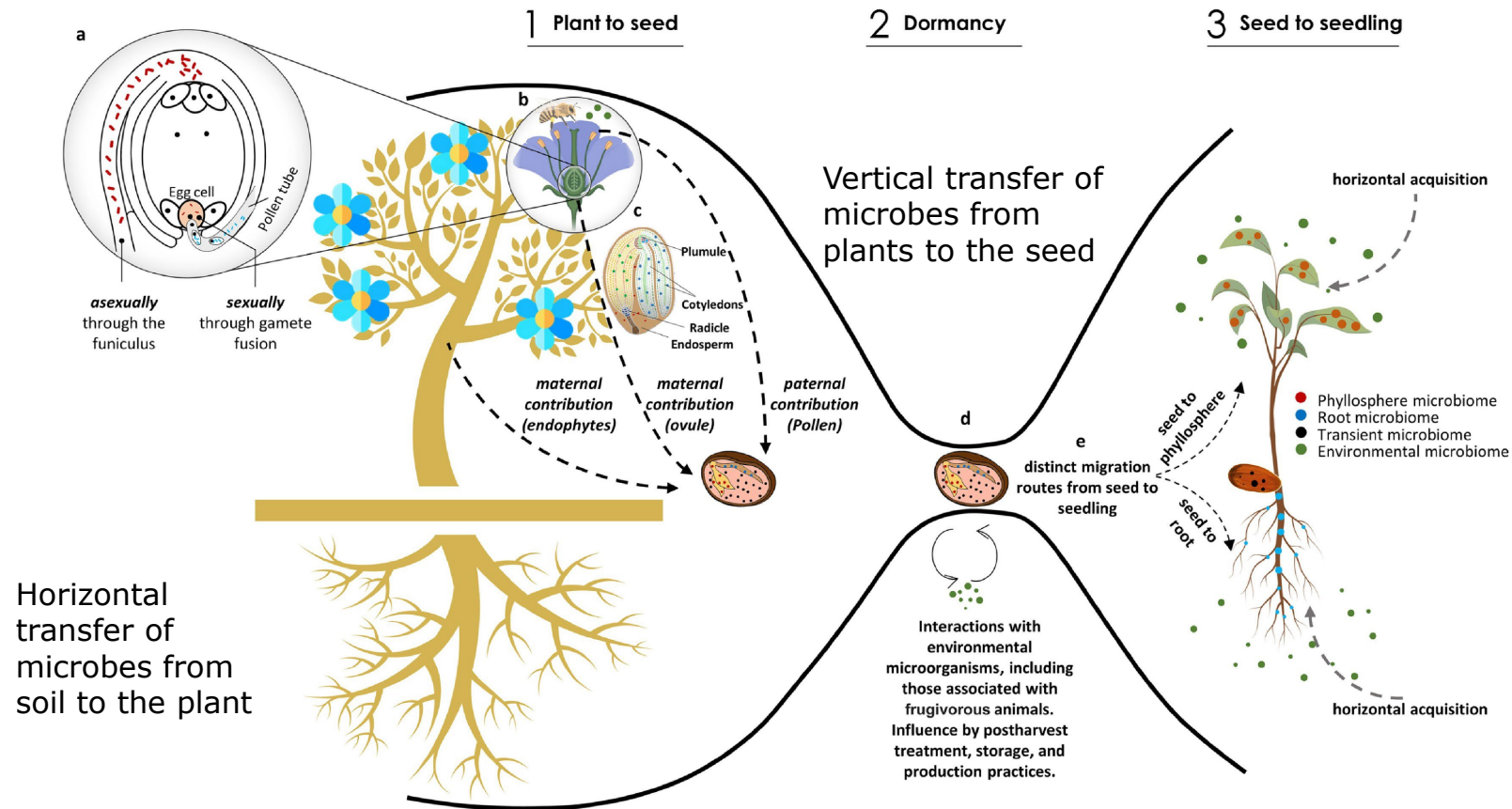
Cultivated peanut

Wild peanut



Packaging of microbes for the next generation: Seed microbiomes

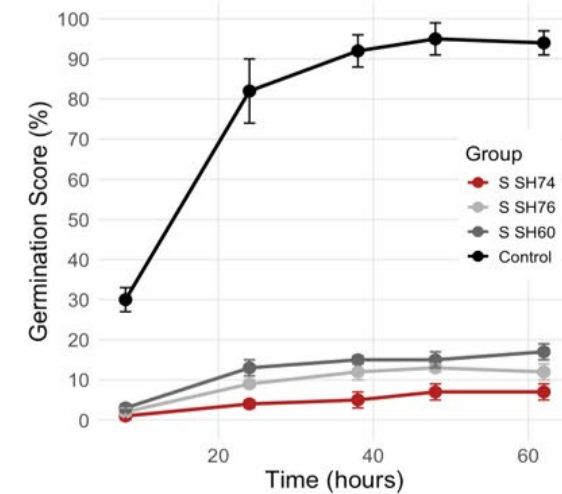
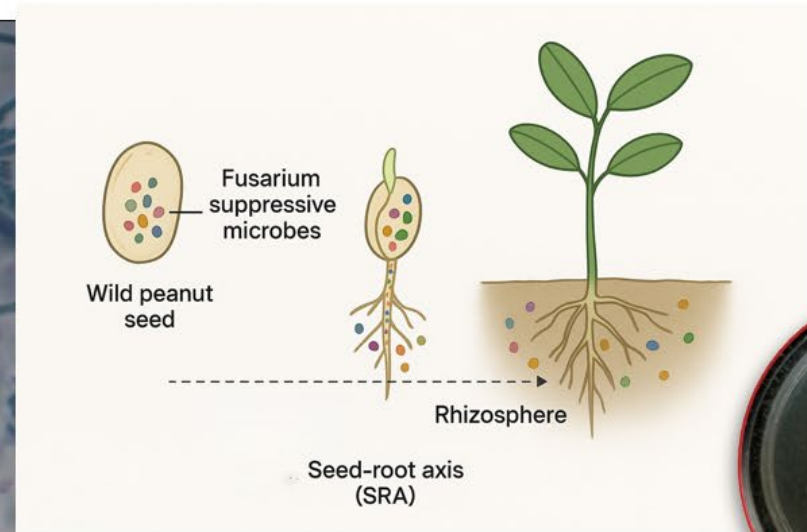
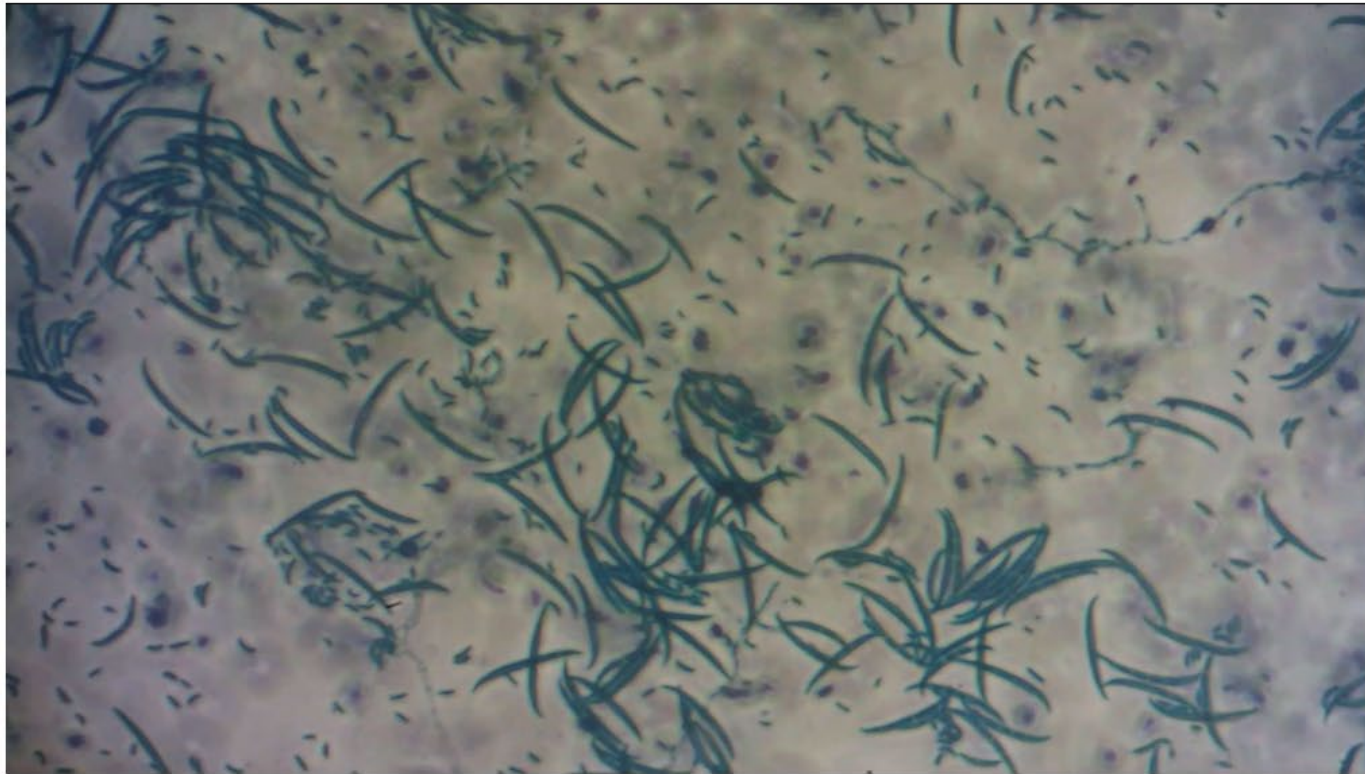
Microbial inheritance in plants



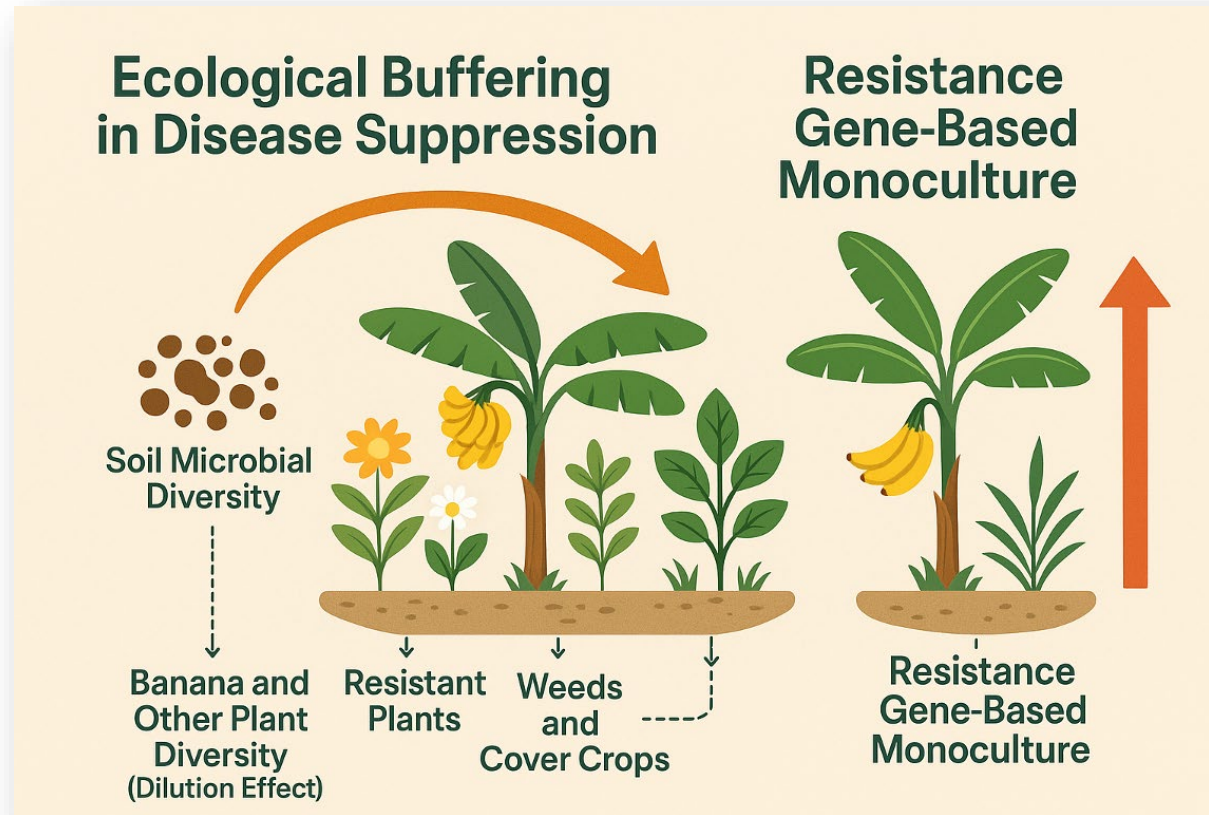
<https://doi.org/10.1016/j.tim.2022.10.009>

Trends in Microbiology

Microbes as a tool to clean Fusarium propagules



From suppressive soils to a resilient cropping system



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.

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