

Microbial Interactions: Essential Part of Below-Ground Biocontrol

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NIOO-KNAW (Microbial Ecology)

WUR (Soil Quality)

Wageningen

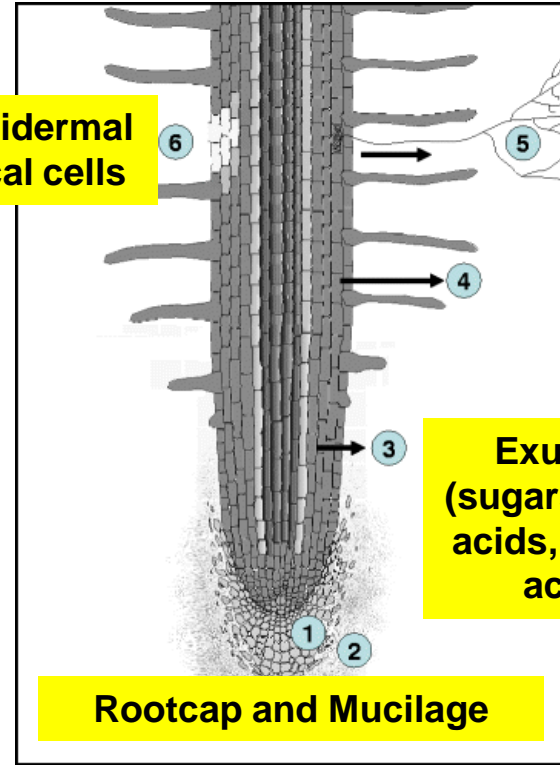
Email: w.deboer@nioo.knaw.nl

Rhizosphere: Hotspot of Microbial Activity

Rhizosphere



Dead epidermal
& cortical cells

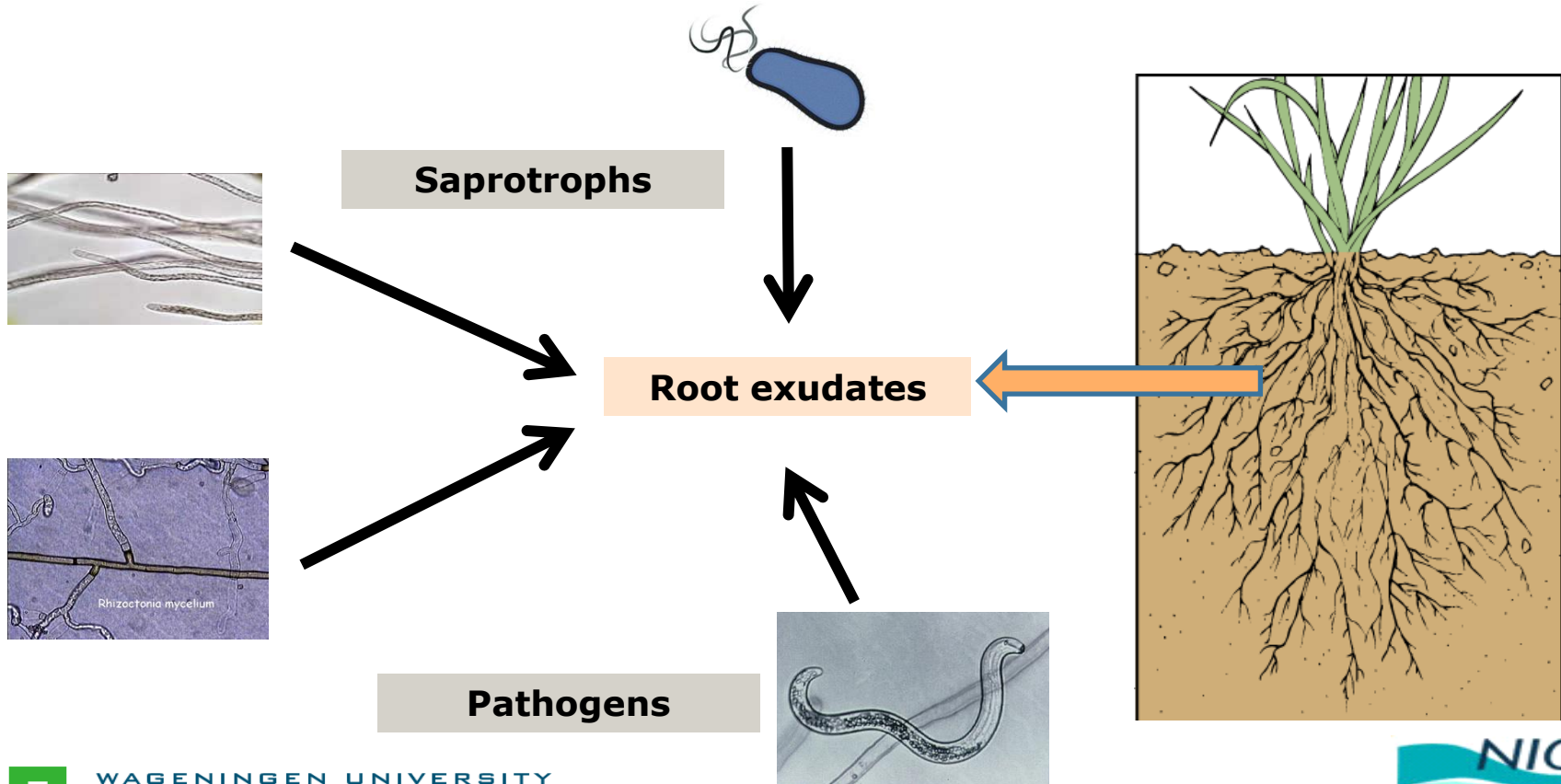


Exudates
(sugars, amino
acids, organic
acids)

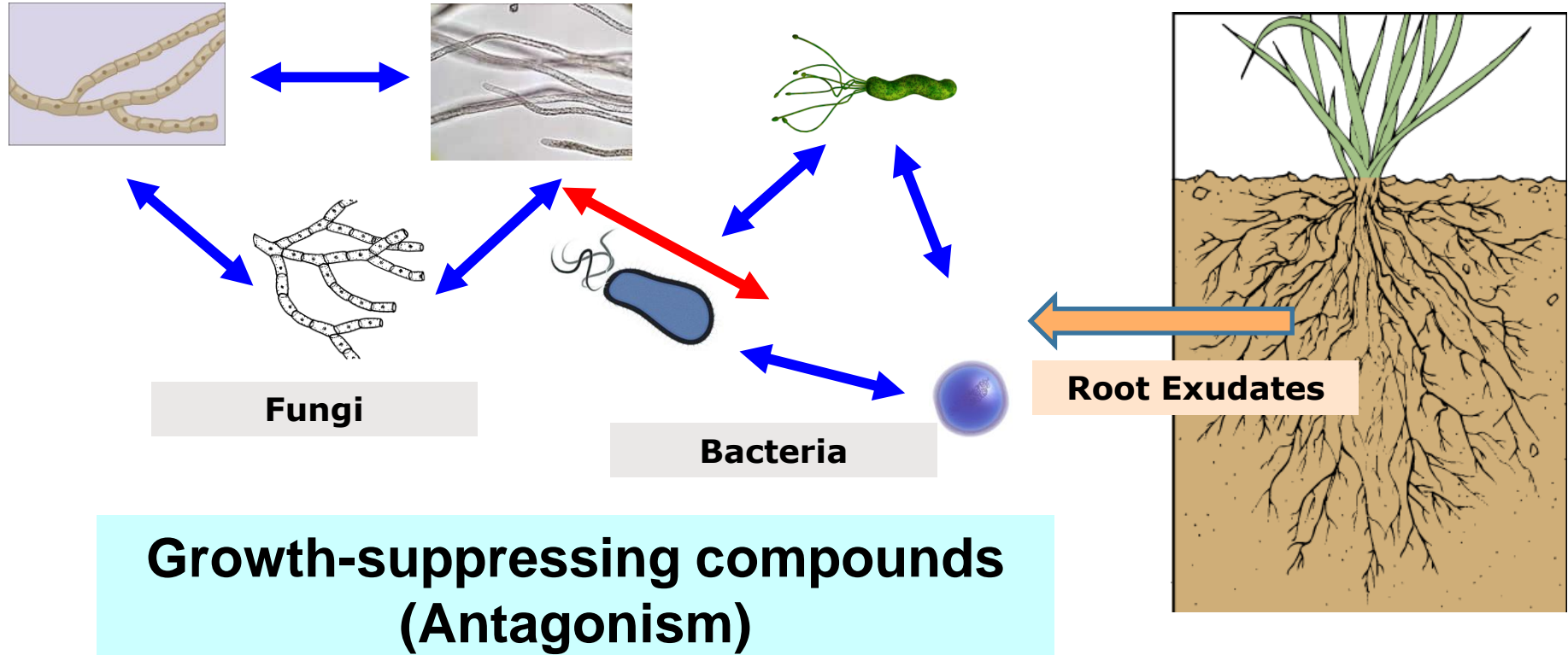
Rootcap and Mucilage



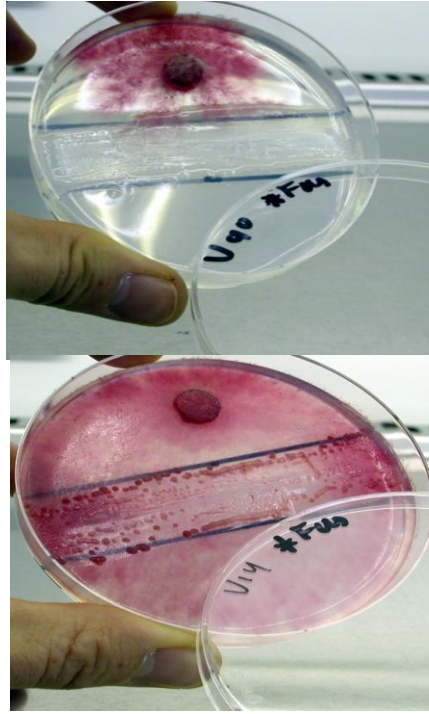
Microbes & Rhizosphere



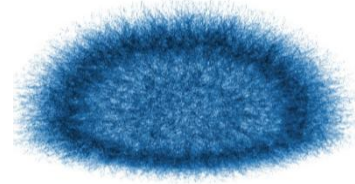
Competition for Root Exudates



Pairwise Interactions – Suppression



Fungal Pathogen



Bacterium I

Pairwise Interaction

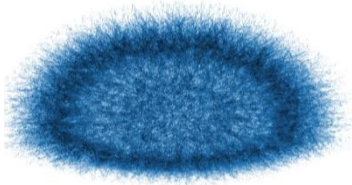


Biocontrol Product



Pairwise Interactions – Suppression

Fungal Pathogen



Bacterium I

Pairwise Interaction

Detailed Mechanisms

Fungus

Defense

Gene Expression

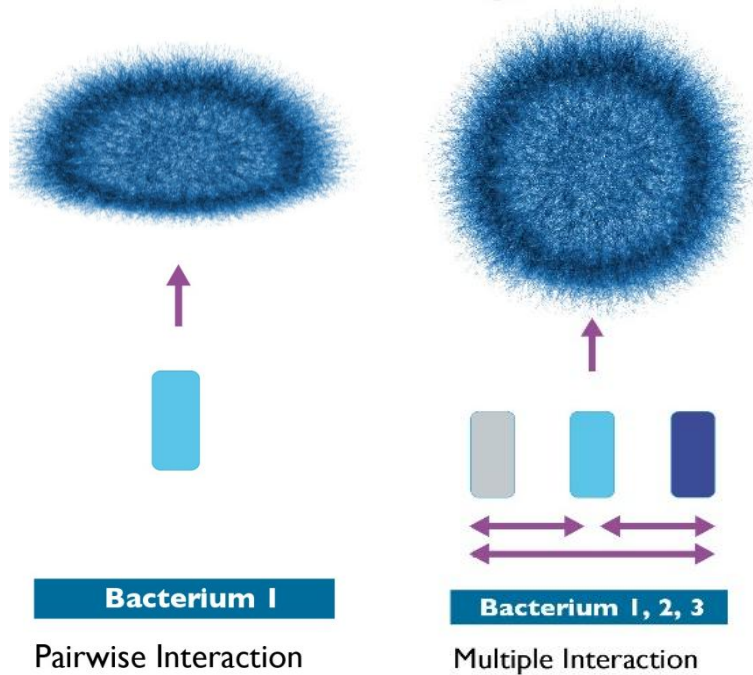
Bacterium

Identity inhibitors
and genes

Regulation inhibitors:
Fungal compounds,
Medium composition



Multiple Interactions - Suppression

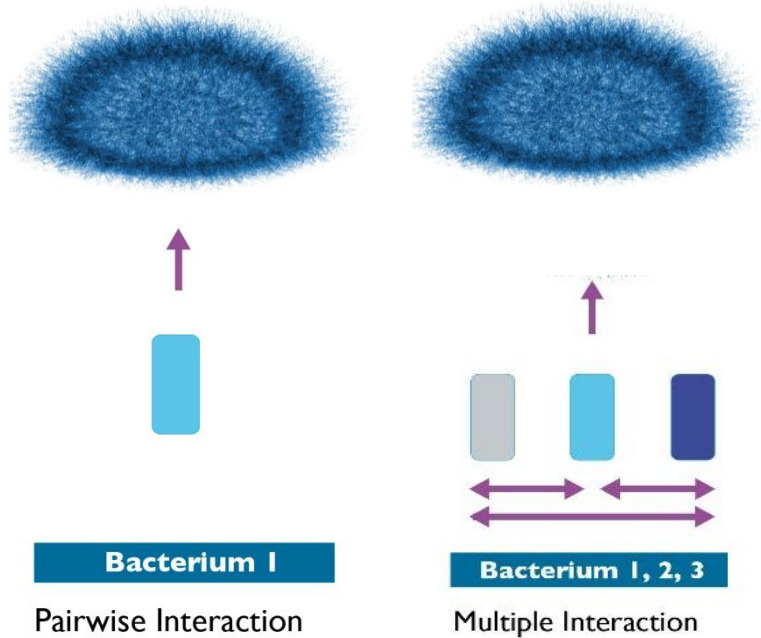


**Bacterial Interactions
&
Suppressing compounds**

Silencing



Multiple Interactions - Suppression

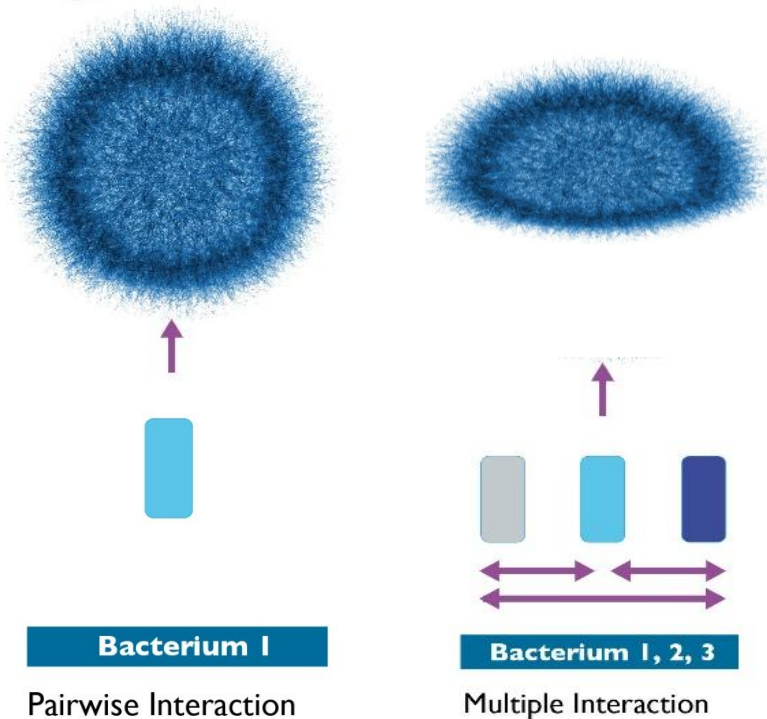


Bacterial Interactions
&
Suppressing compounds

No Change



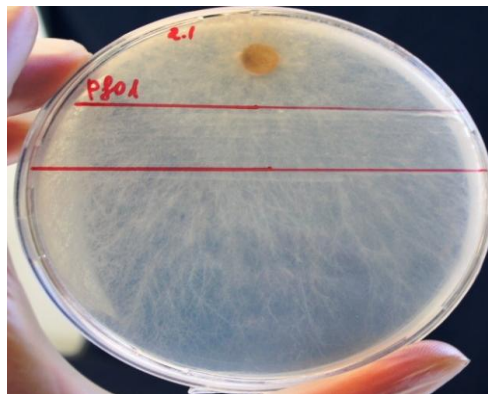
Multiple Interactions - Suppression



Bacterial Interactions
&
Suppressing compounds

Triggering

Stimulation of Suppressing Activity by Interaction

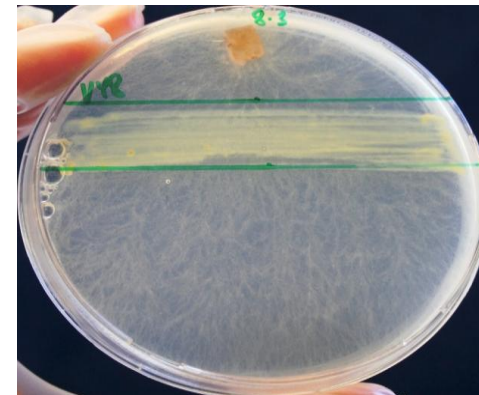


Pseudomonas

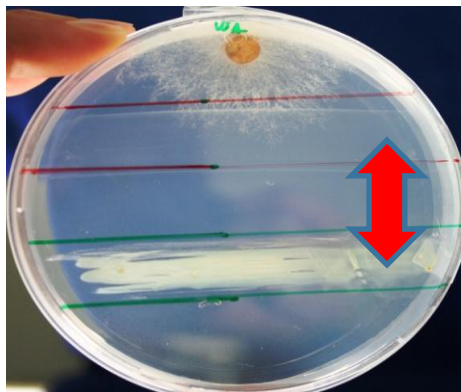
Pseudomonas Zone →

Pedobacter Zone →

← Bacterial Zone →



Pedobacter.



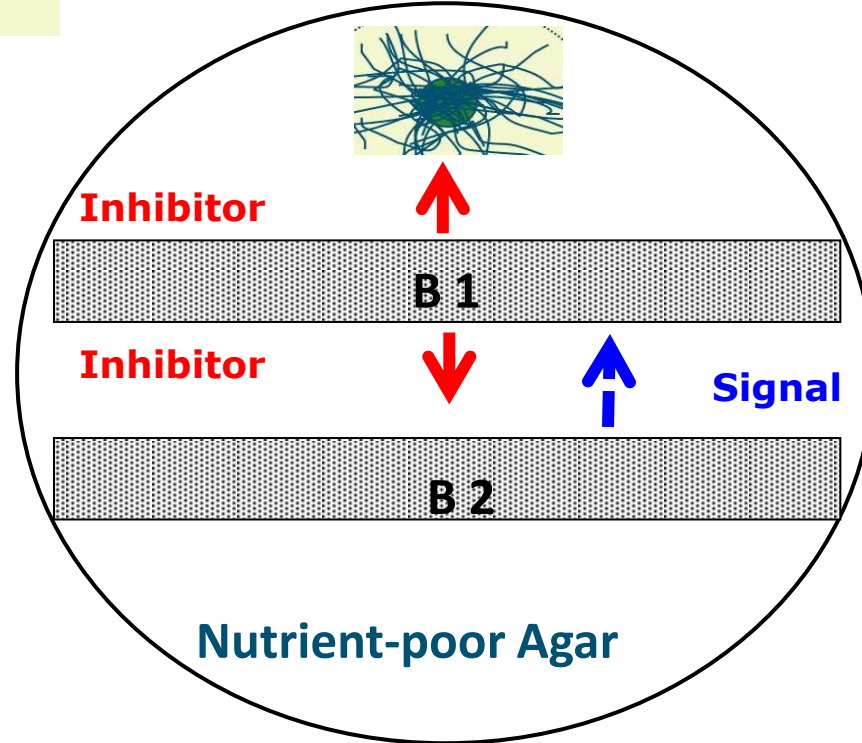
Interaction

Garbeva et al. (2011) ISME J. 5:973-

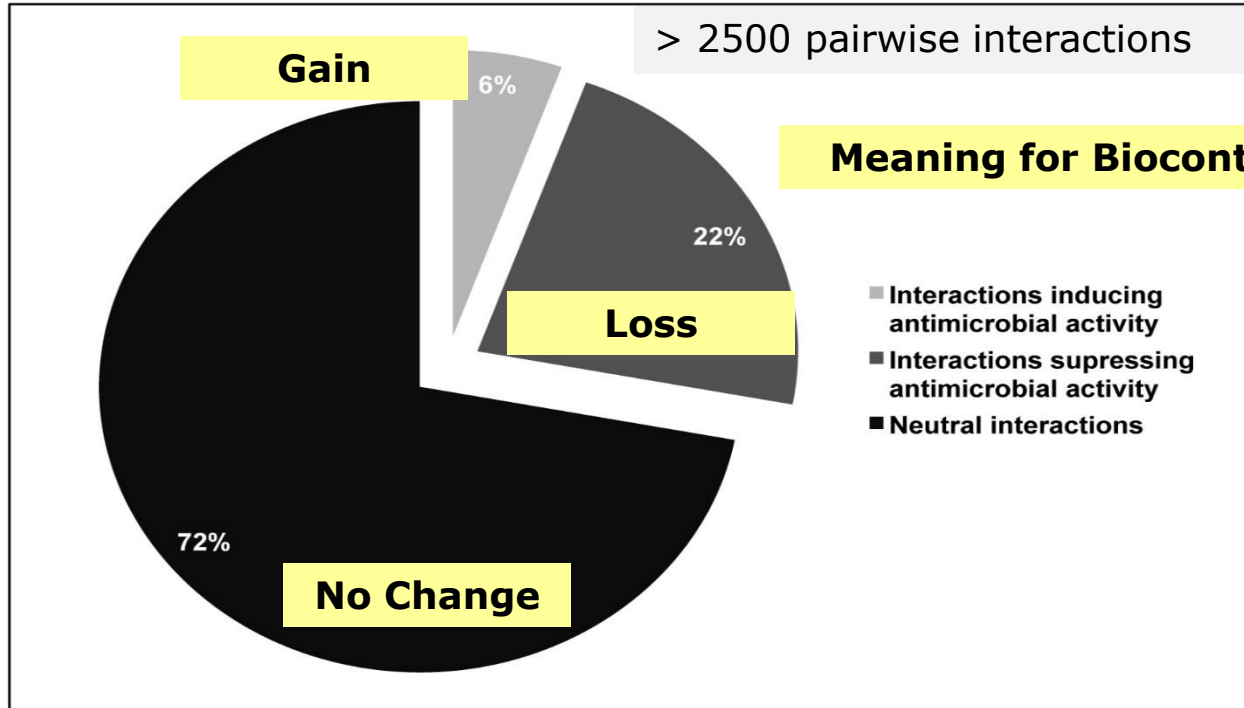
Antibiotic Production during Bacterial Interactions

- Fungus as bioindicator

Broad-spectrum antibiotic: inhibiting both bacteria and fungi

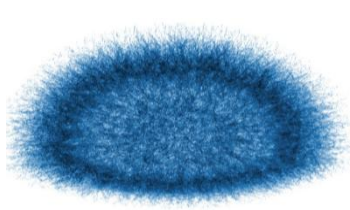


Effect Bacterial Interactions on Suppressing Activity



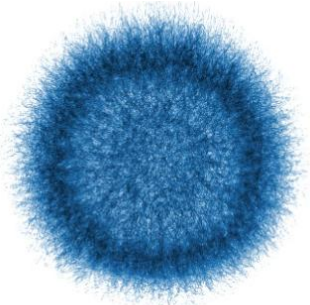
Tyc *et al.* 2014 *Frontiers in Microbiology* 5: 567

Community Interactions - Suppression



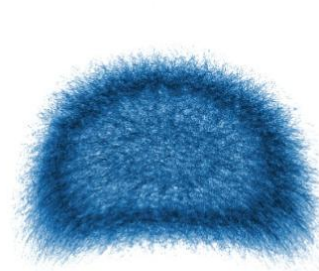
Bacterium 1

Pairwise Interaction



Bacterium 1, 2, 3

Multiple Interaction



Bacterium 1, 2, 3, 4, 5, ...

Community Interaction



Microbial Properties

Abundance

Activity

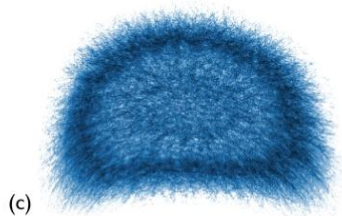
Diversity

Key species

~~Details on Interactions~~

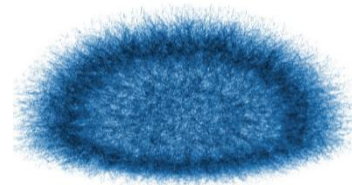


Community versus Pairwise Interactions



Bacterium 1, 2, 3, 4, 5, ...

Communities:
Multiple Interactions
Functional Redundancy
(catabolism, anabolism)



Bacterium I

Pair-wise:
One Interaction
One Mechanism



Examples Redundancy Rhizoctonia Suppression

Bacterial species

Bacillus subtilis RB14

Burkholderia pyrrocinia BC11

Streptomyces griseoviridis

Pseudomonas fluorescens DR54

Serratia plymutica HRO-C48

Many more

Inhibiting Mechanism

Iturin A, Surfactin

Lipopeptide AFC-BC11

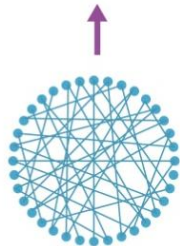
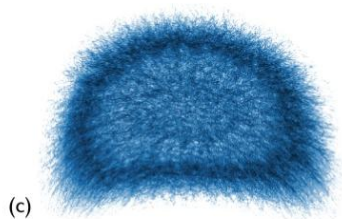
Chitinases, polyenes,
macrolactones

Vicosinamide

Haterumalide, volatiles

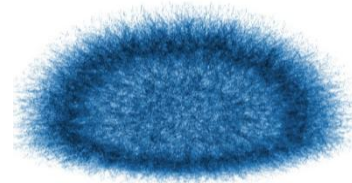
Many more

Community versus Pairwise Interactions



Bacterium 1, 2, 3, 4, 5, ...

Communities:
Multiple Interactions
Functional Redundancy
(catabolism, anabolism)



Bacterium 1

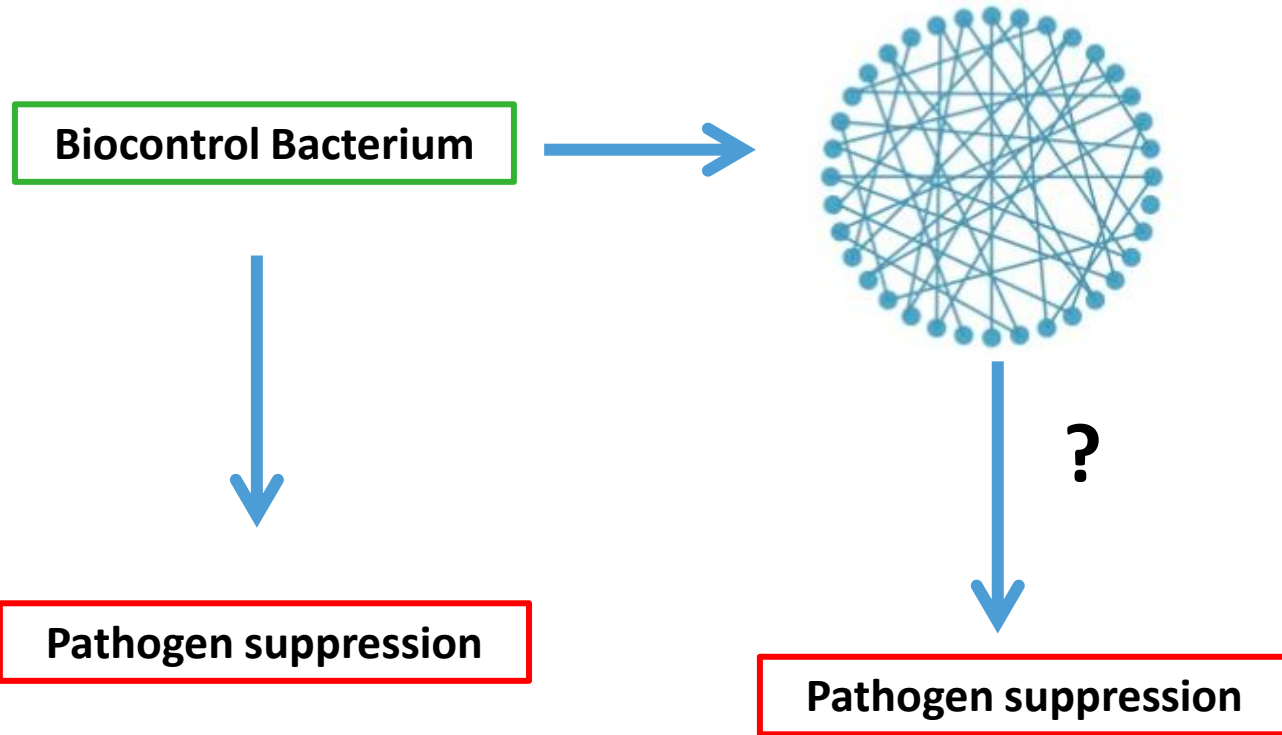
Pair-wise:
One Interaction
One Mechanism

Explanation

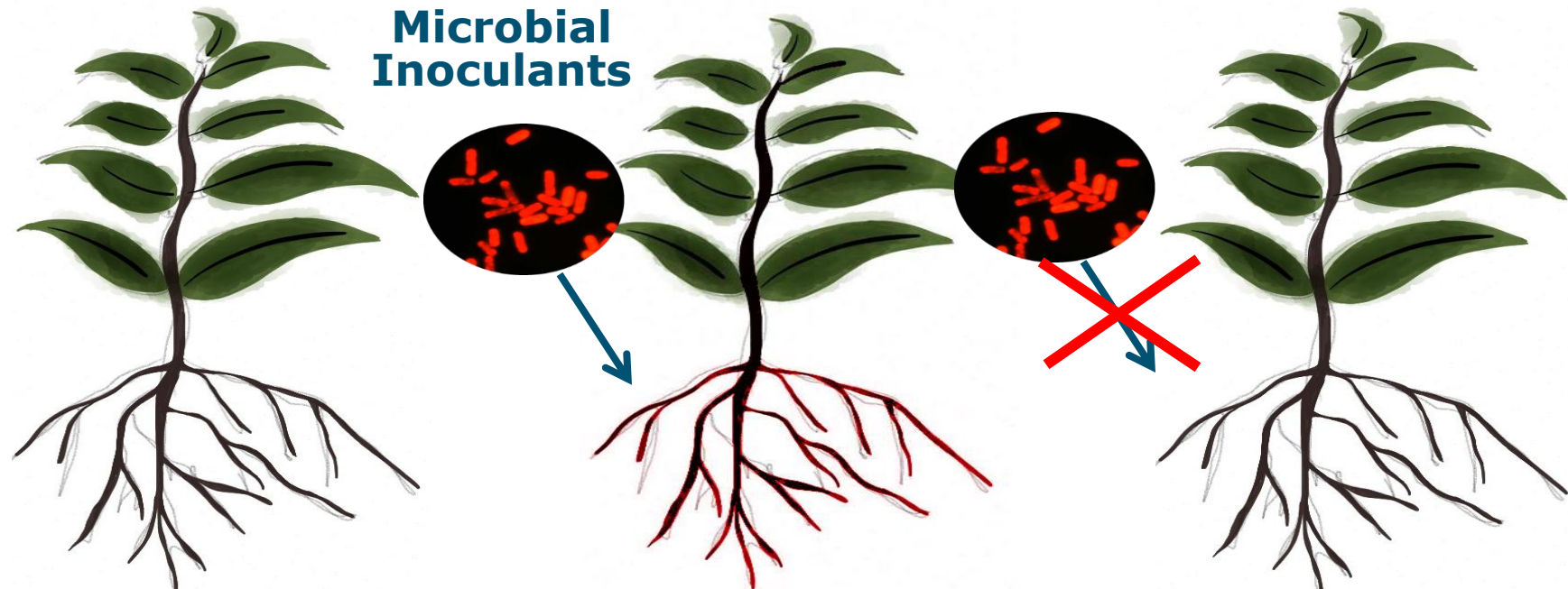


?

Microbial Inoculants & Indigenous Microbial Communities

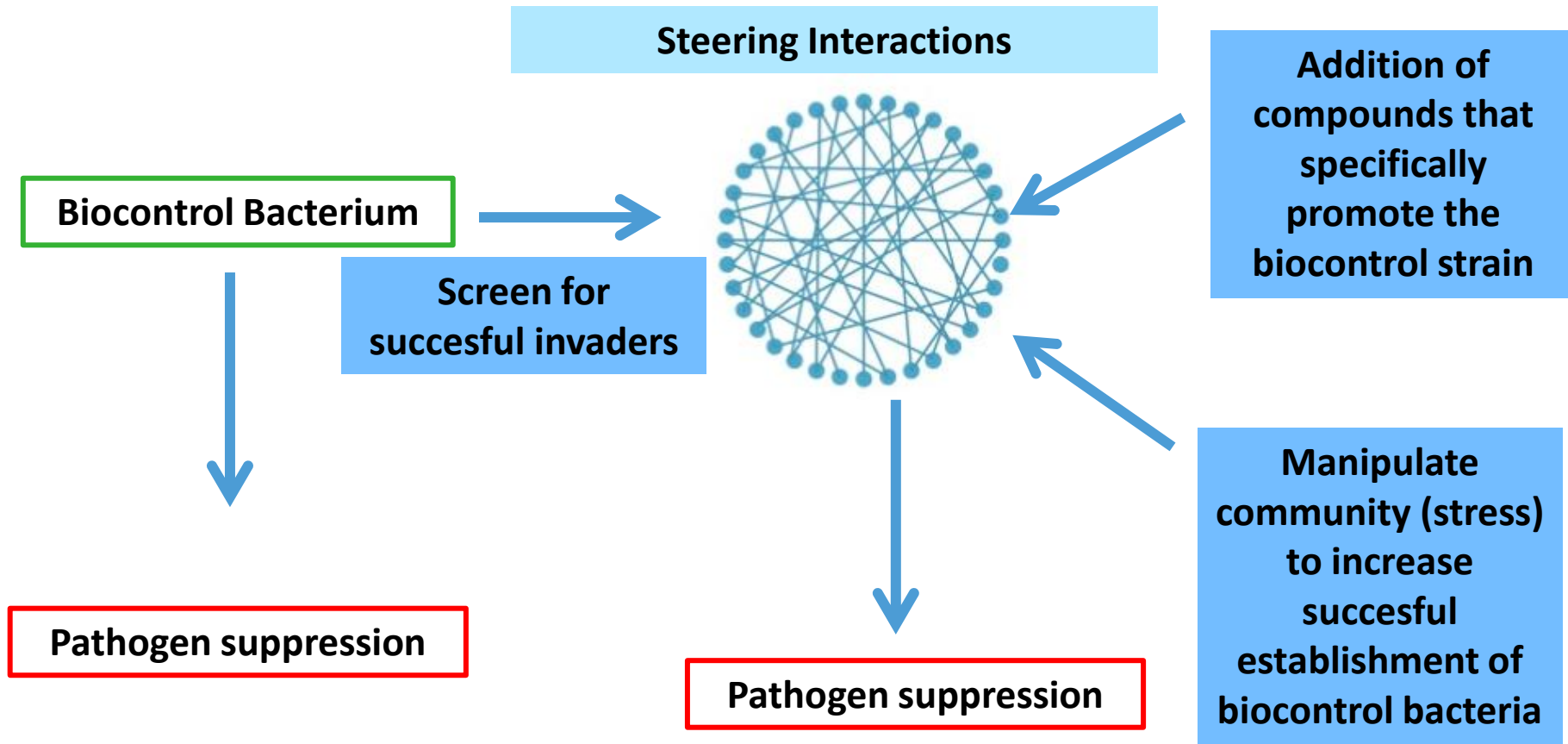


Expected versus real behavior of biocontrol inoculants



**Resistance against biocontrol “invaders”
by indigenous rhizosphere bacterial communities**

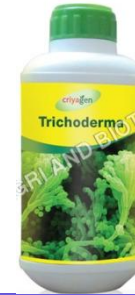
Possibilities to Improve Success Biocontrol Bacteria



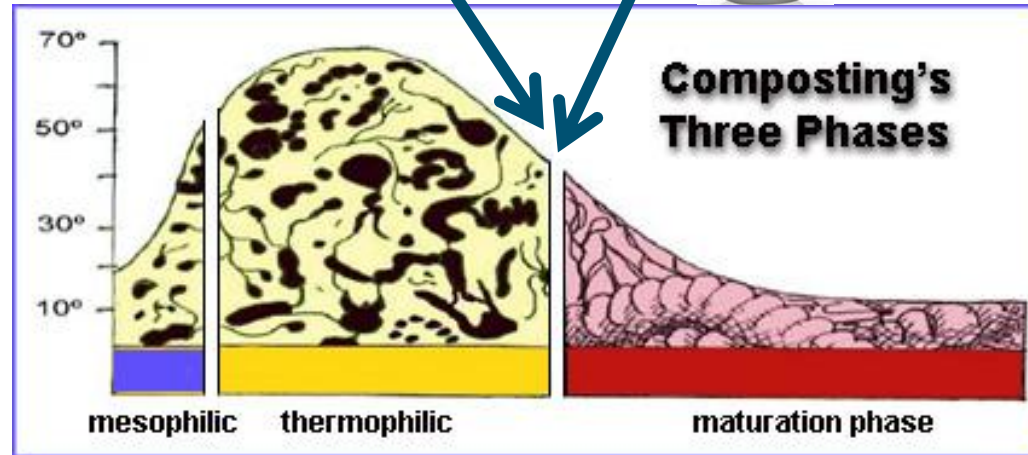
Example to Improve Success Microbial Inoculants



Transient Phase
(New colonisation)



Microbial
Inoculant



Steering Indigenous Rhizosphere Microbial Communities

Biol Fertil Soils (2012) 48:489–499
DOI 10.1007/s00374-012-0691-4

REVIEW

Manipulating the soil microbiome to increase soil health and plant fertility

Jacqueline M. Chaparro • Amy M. Shefflin •
Daniel K. Manter • Jorge M. Vivanco

Make use of beneficial microbes that are adapted to the local situation !

Crop Farming = Microbe Farming

**Agricultural Management
(crop choice, organic
amendments, tillage)**

**Increased
disease control**

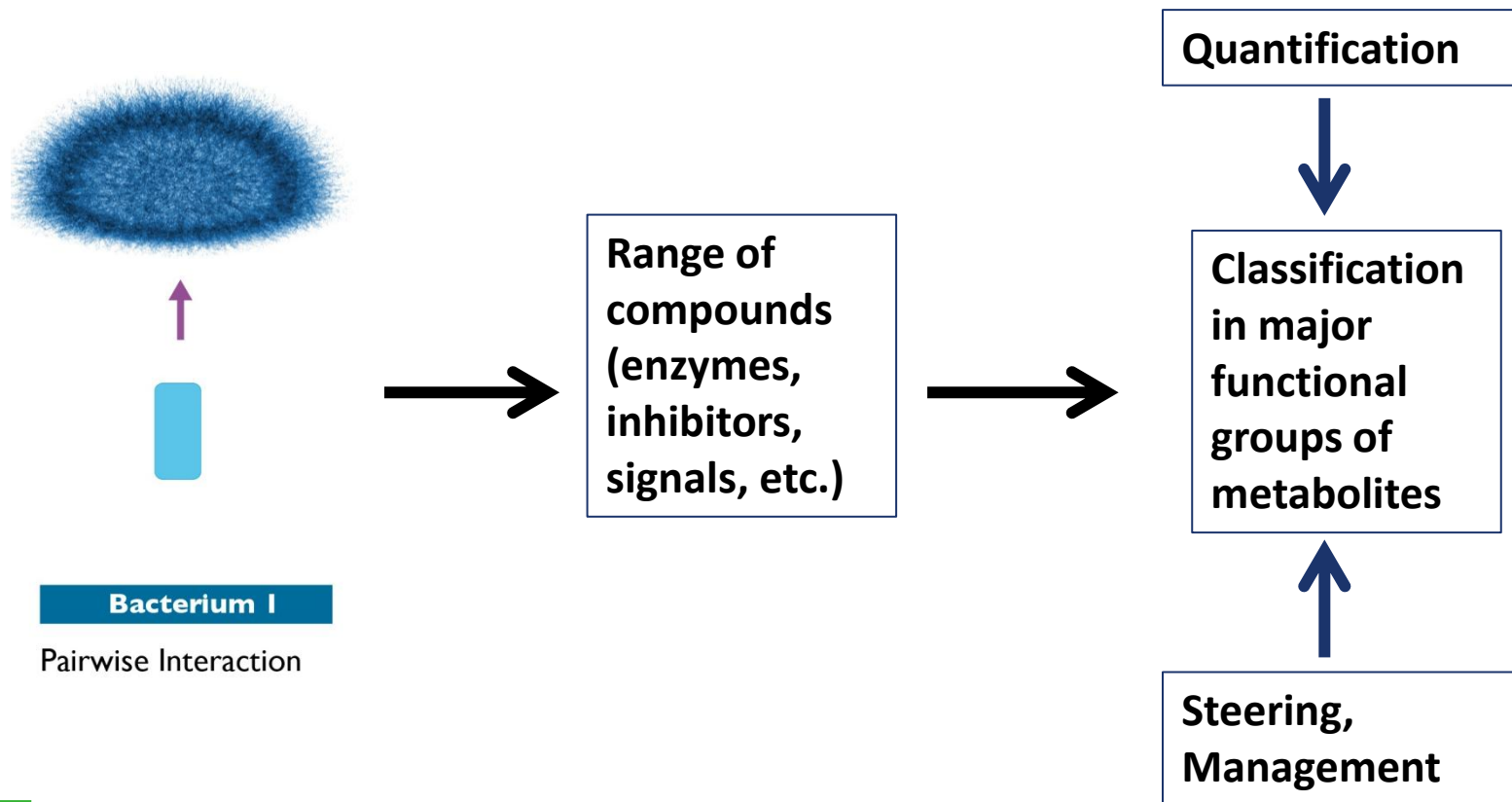


**Shift in microbial
community functioning**

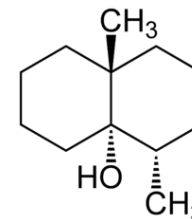
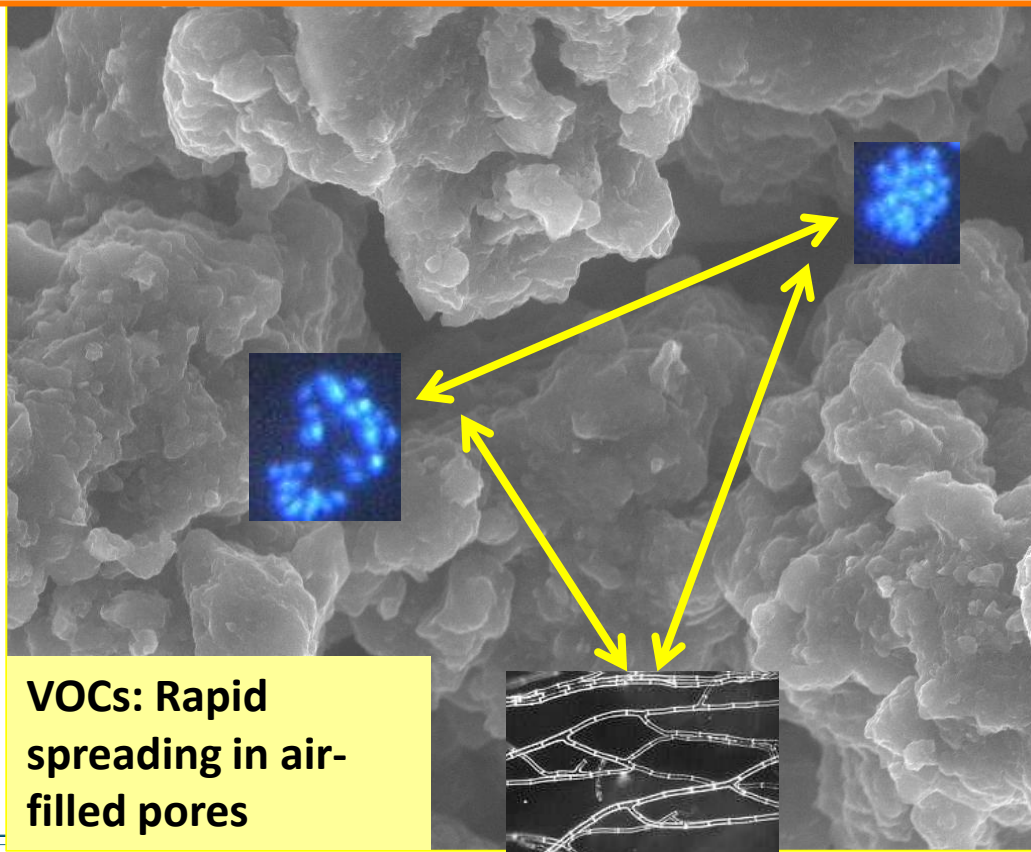


Which microbial functions should be stimulated ?
How can these functions be stimulated ?

Extrapolation of Pairwise Fungal-Bacterial Interactions

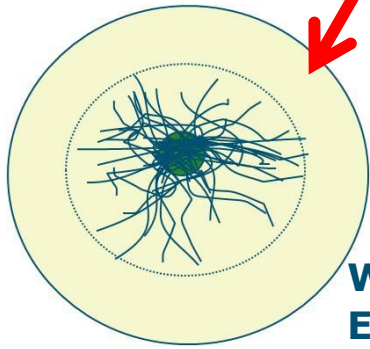
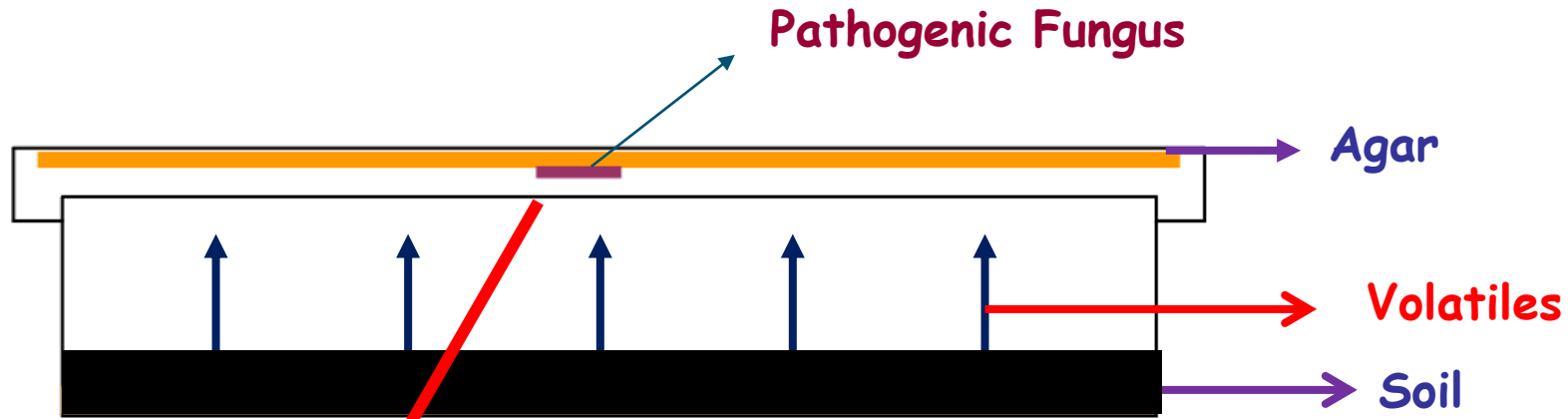


Competition on a Distance: Suppressing VOCs (Volatile Organic Compounds)

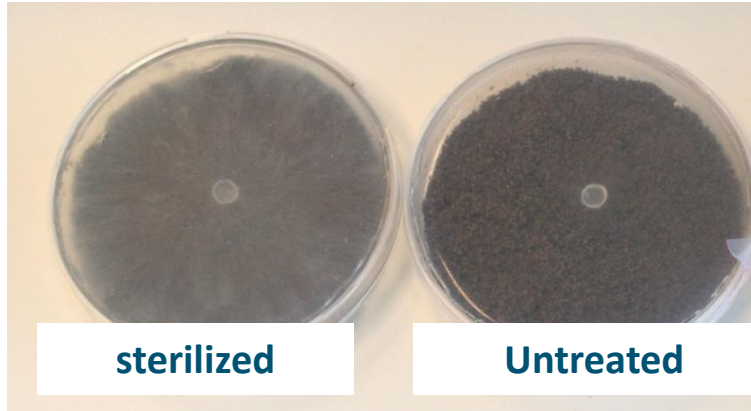


Geosmin

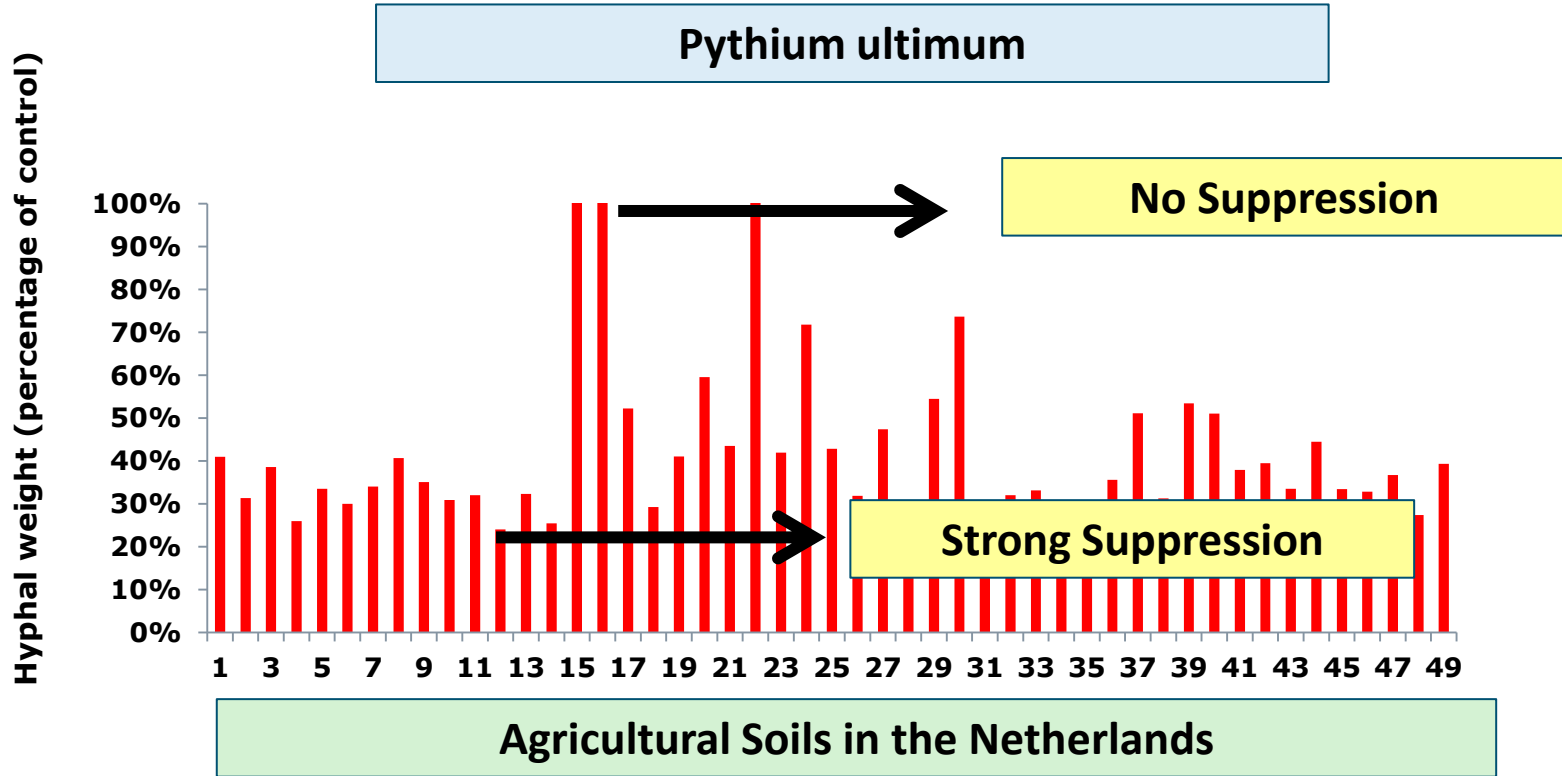
Screening for Volatile-Suppression in Soils



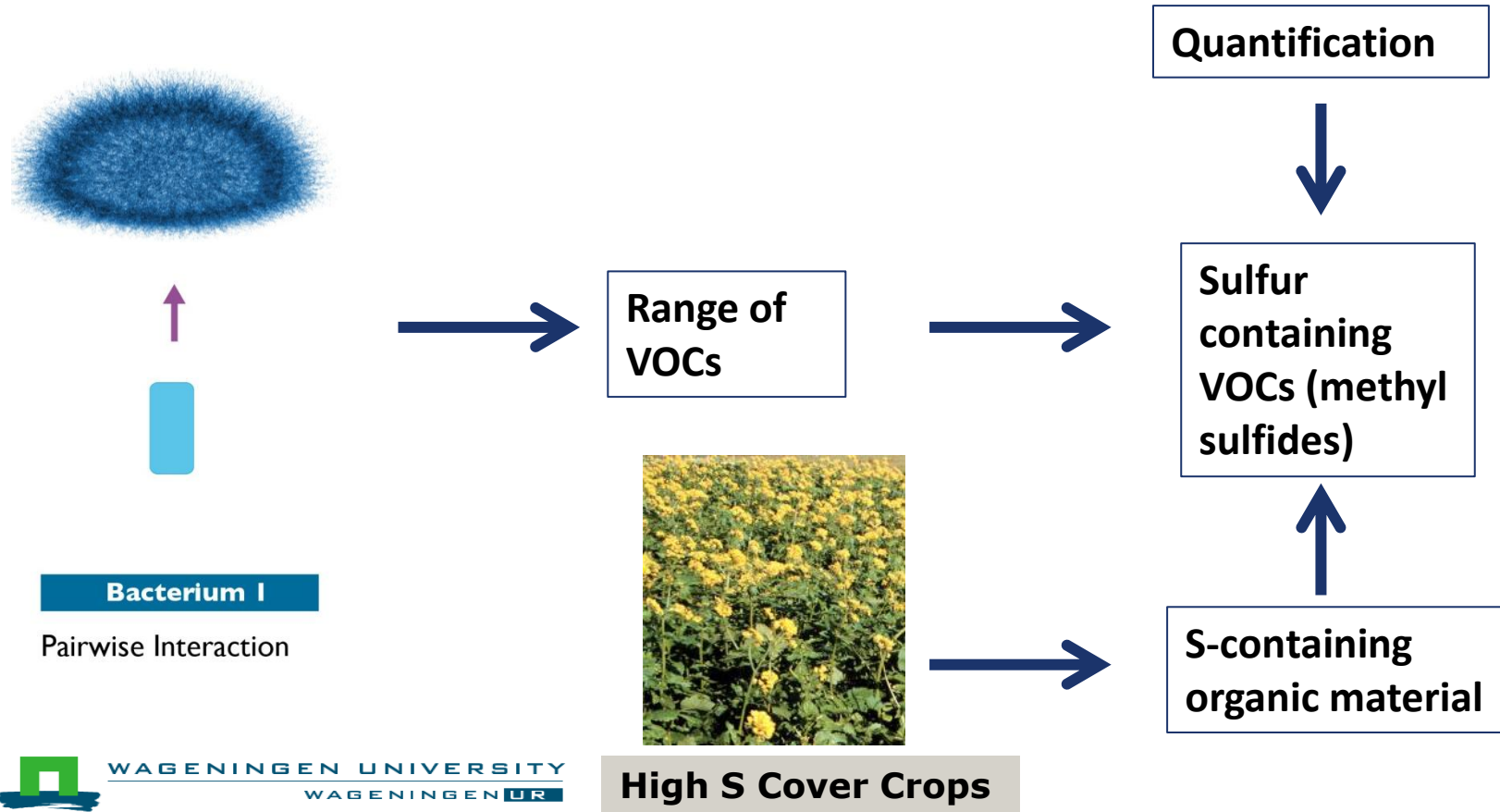
**Weight or
Extension**



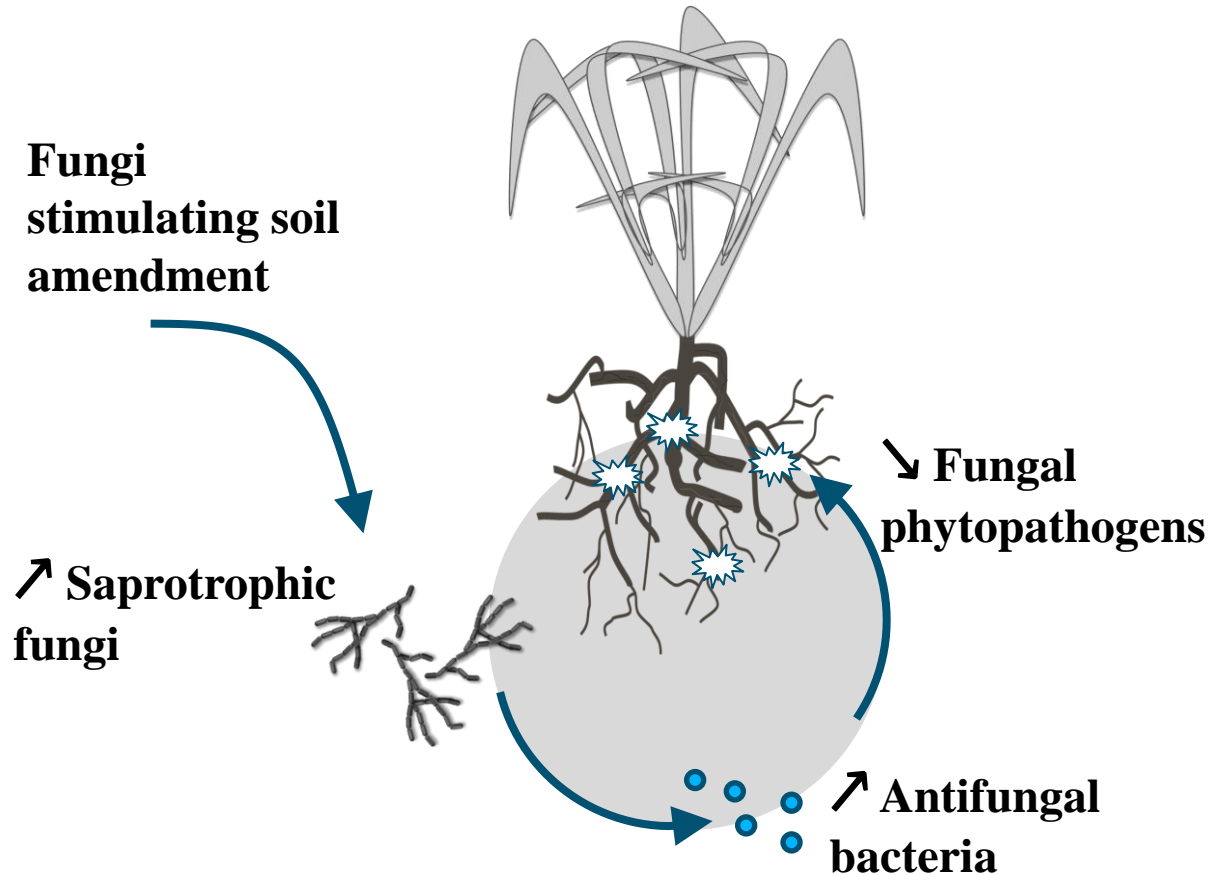
Volatiles & Natural Disease Suppression



Link between Pairwise and Community Functioning



SaproFeed: Application of Competition in Agriculture



Conclusion

Microbial interactions lay at the basis of success and failure of microbe-based biocontrol

Microbial interactions do form the basis for developing strategies to improve biocontrol