GEORG-AUGUST-UNIVERSITÄT
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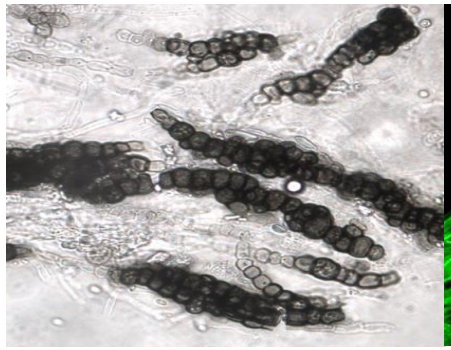
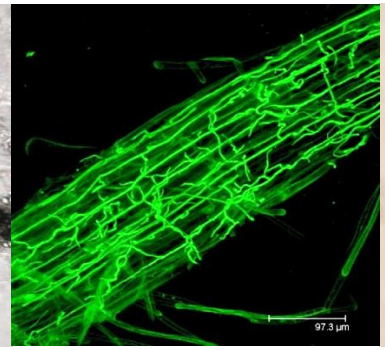
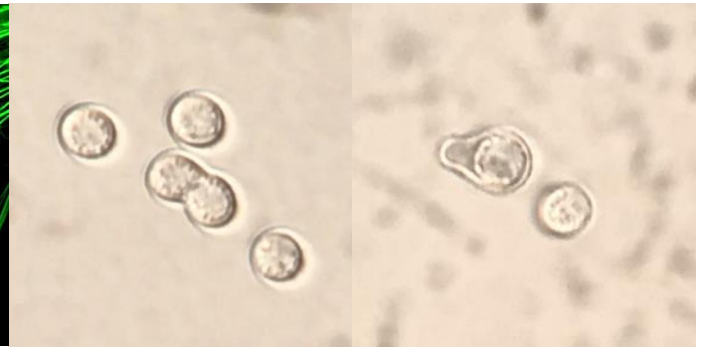
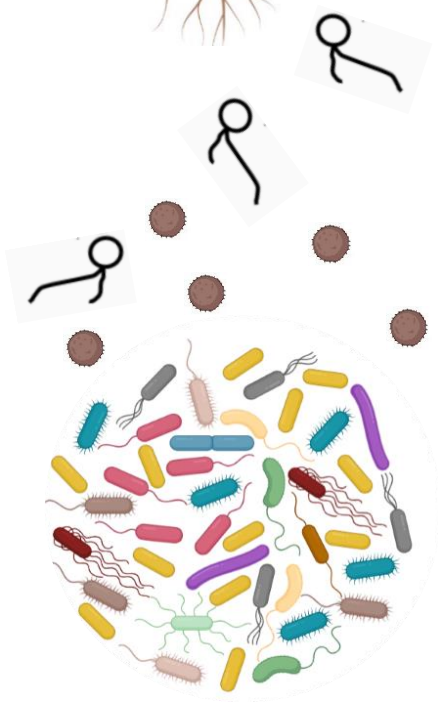






GCIRC Technical Meeting, Cambridge, 10 April 2025

Regulation of dormancy and germination of inoculum of *Plasmodiophora brassicae* and *Verticillium longisporum* in the soil



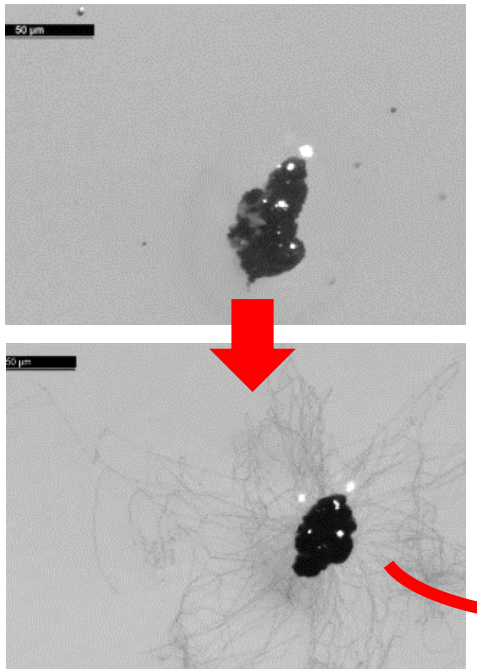
Yao Wang, Xiaorong Zheng, Sarenqimuge Sarenqimuge &
Andreas von Tiedemann

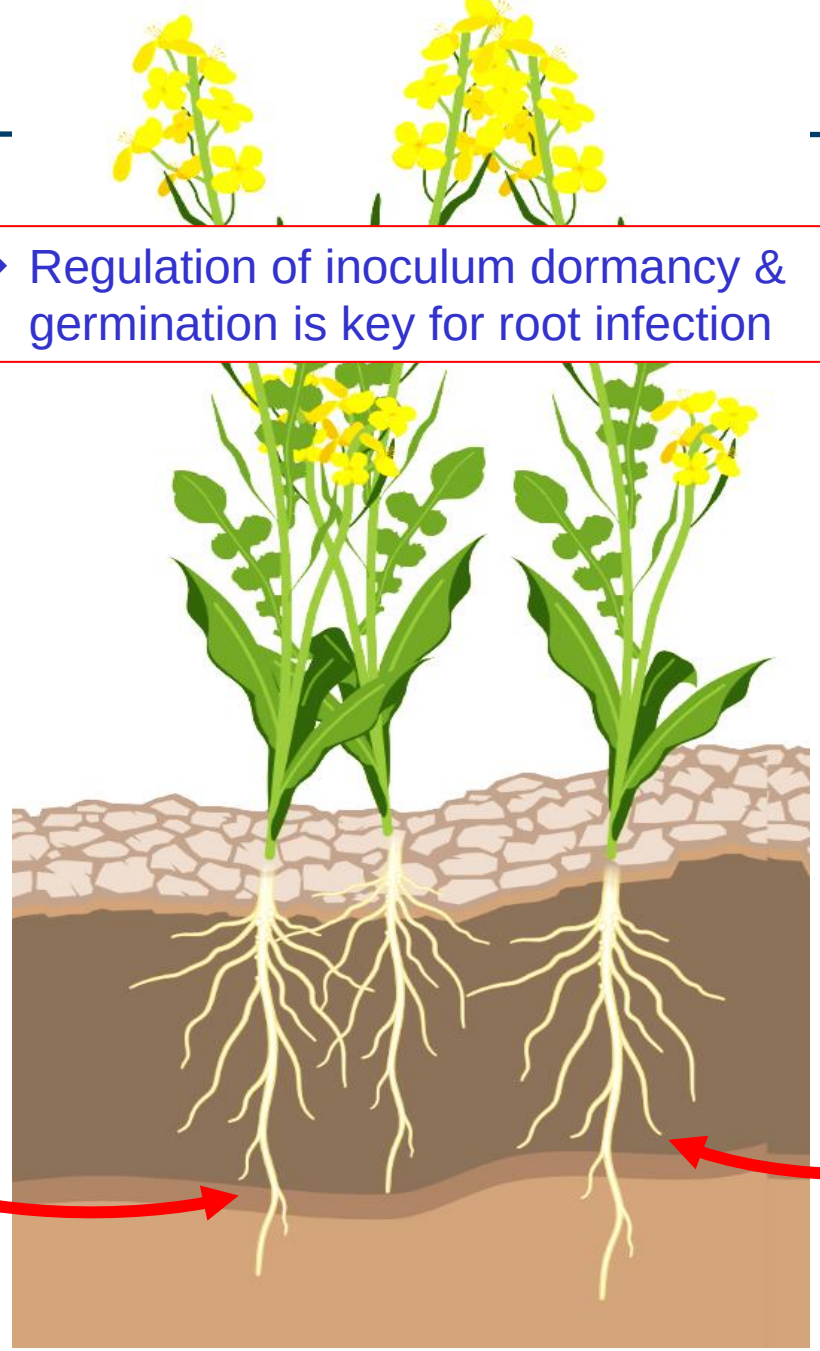
Division of Plant Pathology and Crop Protection, Department of Crop Sciences, University of Goettingen, Germany

Sarenquimuge
Sarenquimuge

❖ Regulation of inoculum dormancy & germination is key for root infection

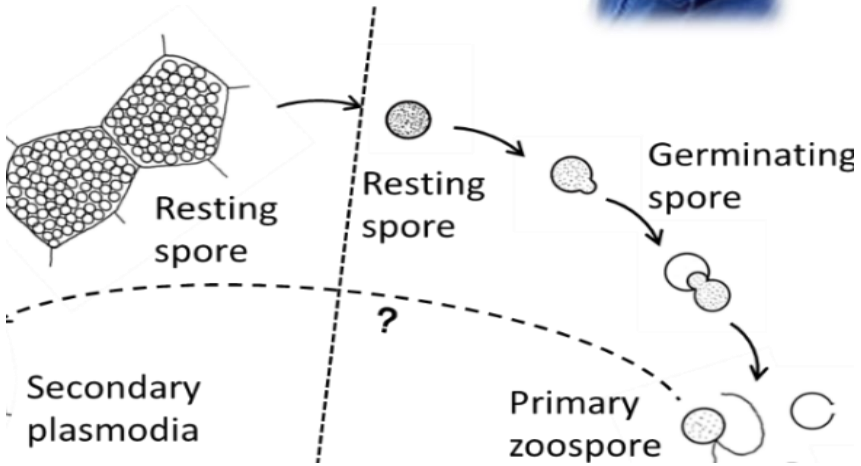
Verticillium longisporum

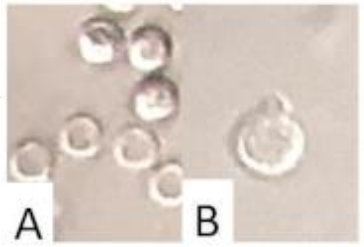




Plasmodiophora brassicae

Yao Wang

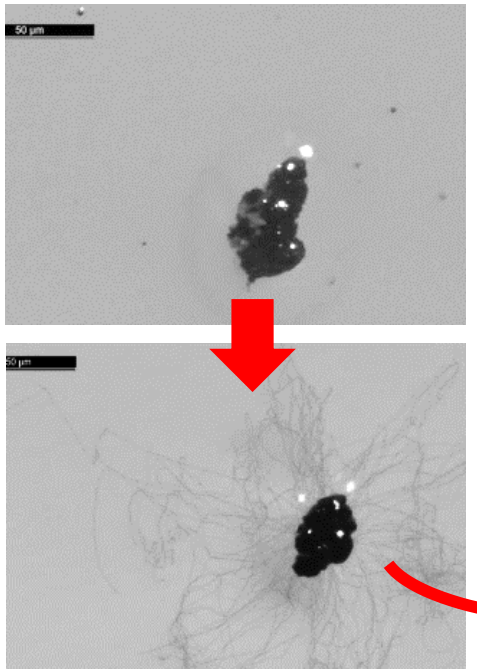


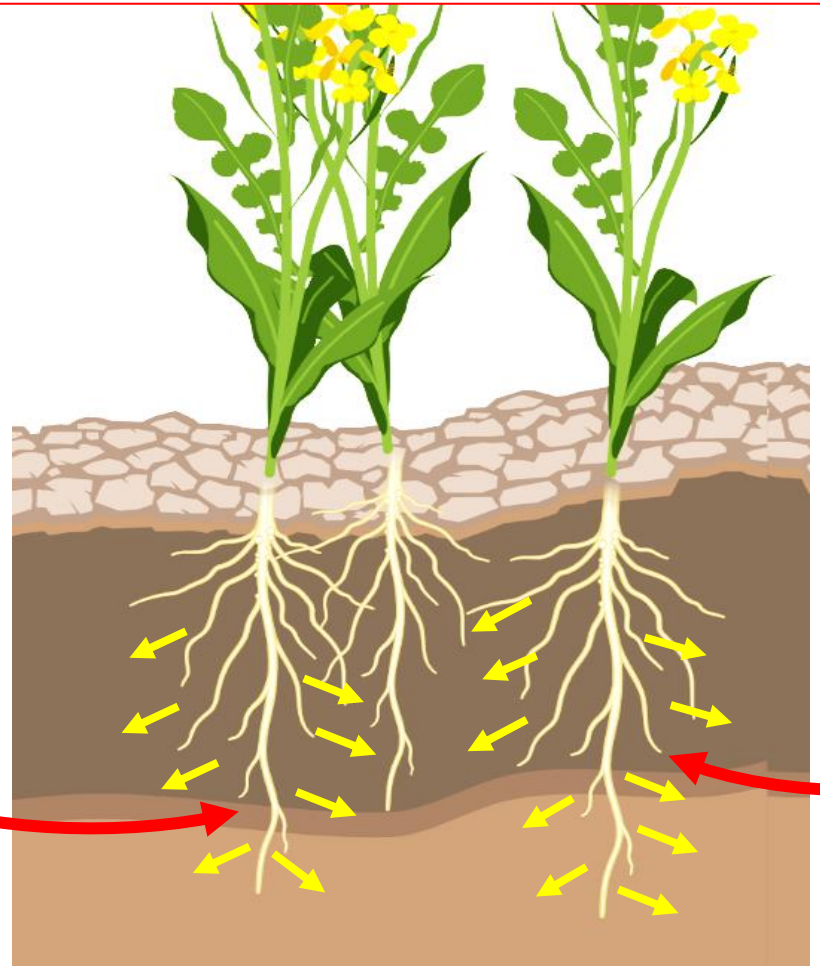


- Until recently, host root exudates were believed to induce germination to enable root infection.

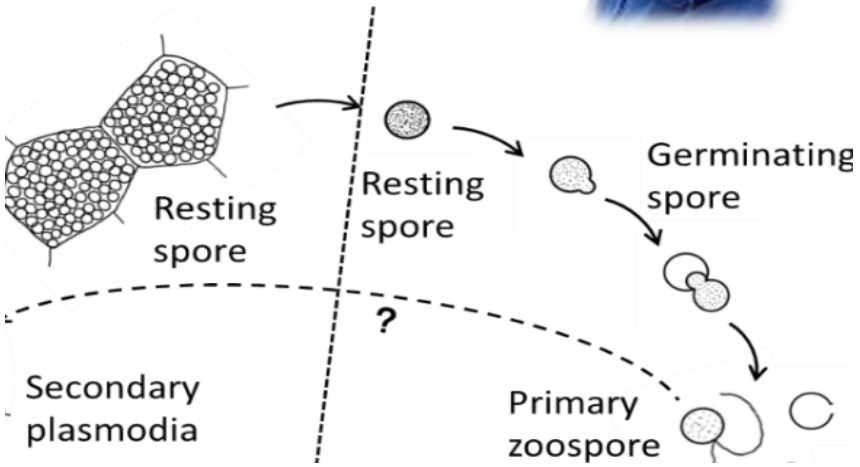
Sarenquimuge
Sarenquimuge

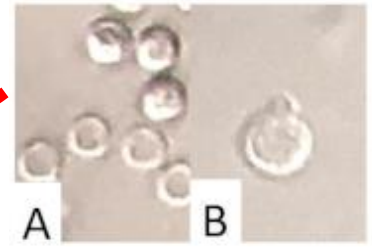
Verticillium longisporum





Plasmodiophora brassicae



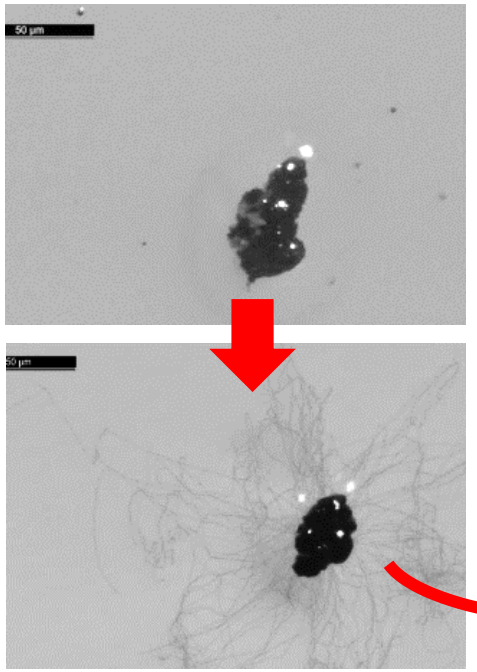


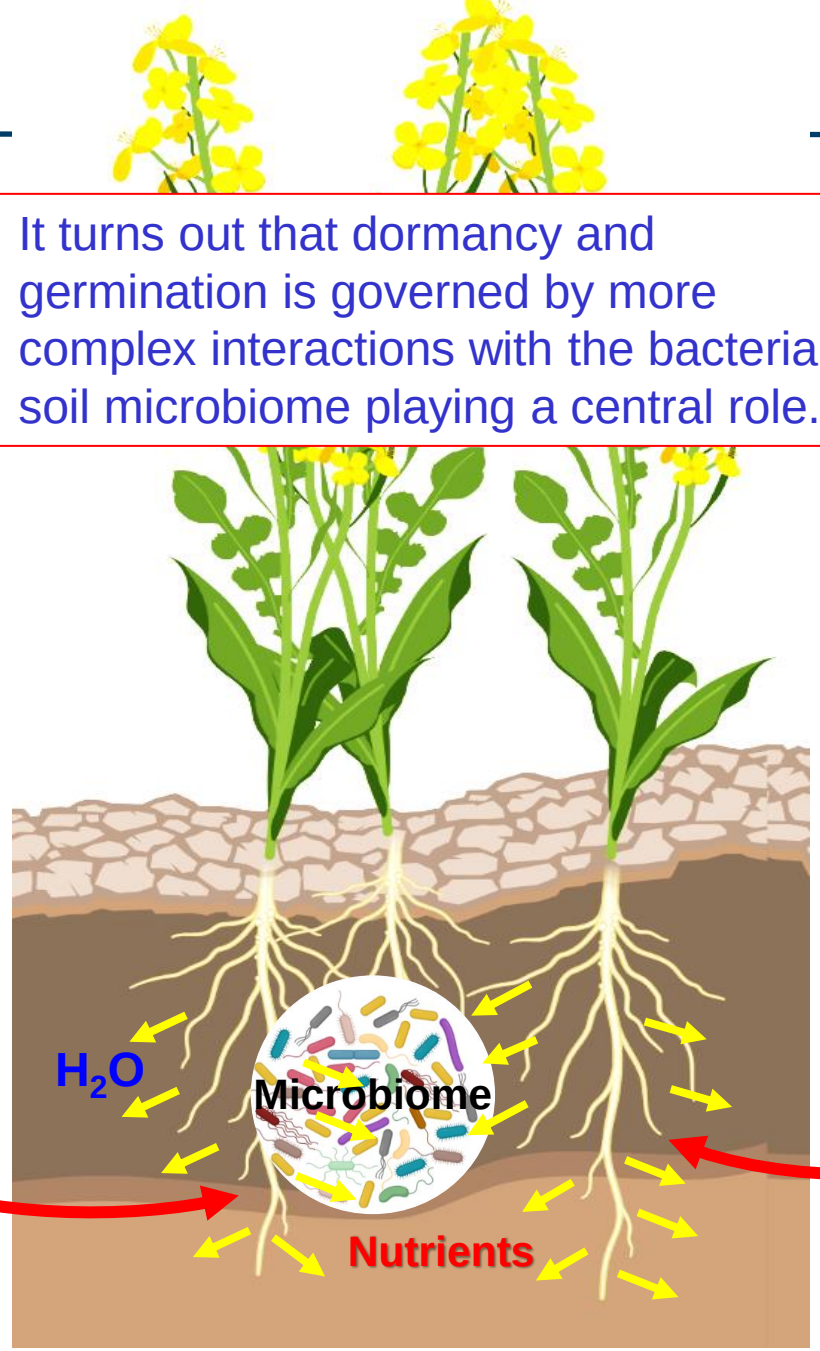
Yao Wang

- It turns out that dormancy and germination is governed by more complex interactions with the bacterial soil microbiome playing a central role.

Sarenquimuge
Sarenquimuge

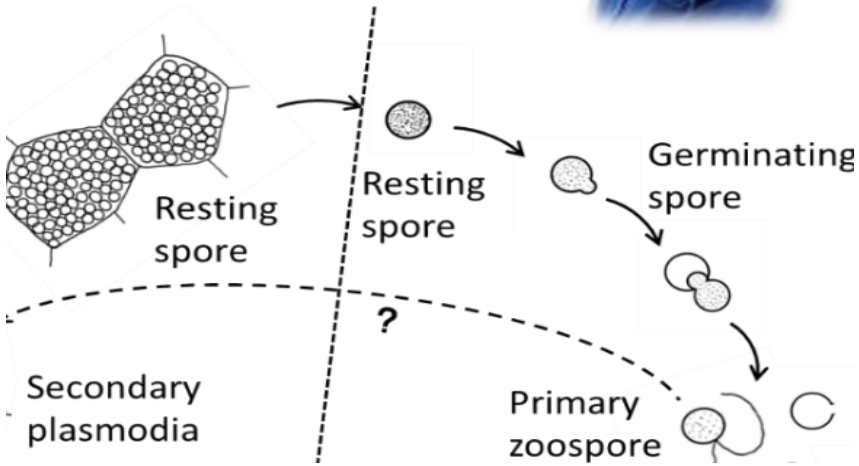
Verticillium longisporum

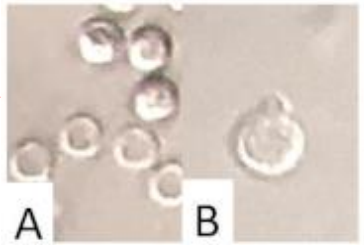




Yao Wang

Plasmodiophora brassicae

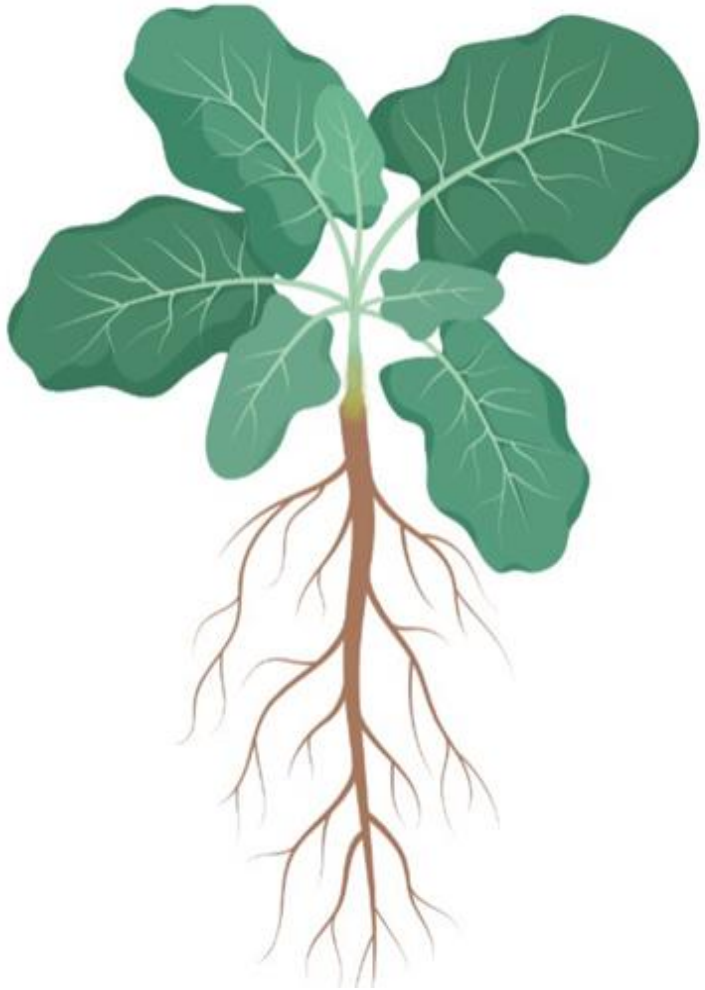




S. Sarenqimuge

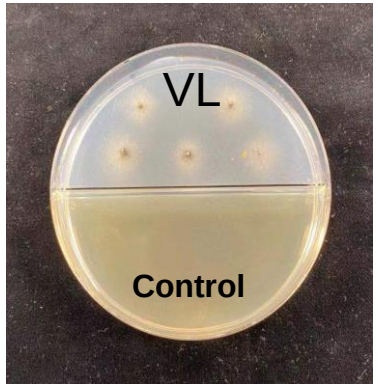
- In unsterile soil and in the absence of root exudates, soil bacteria suppress germination of microsclerotia and disable root infection

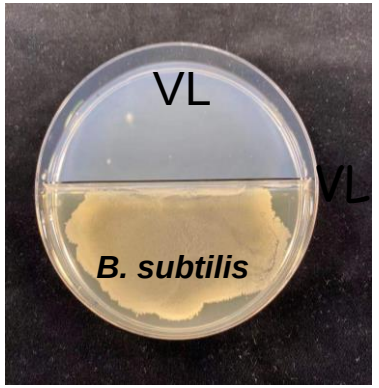
Verticillium longisporum

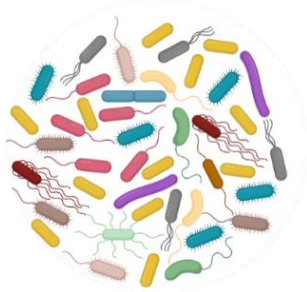


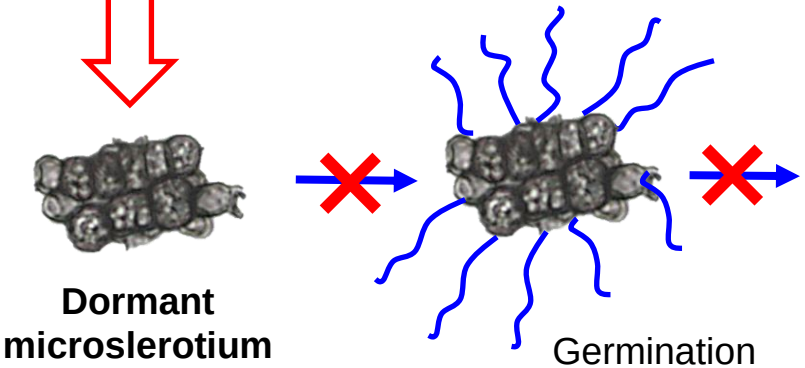
Sarenqimuge, S. *et al*., *Front Microbiol*, 2022

- Volatile fatty acids emitted by soil bacteria inhibit ms germination.









Dormant microslerotium

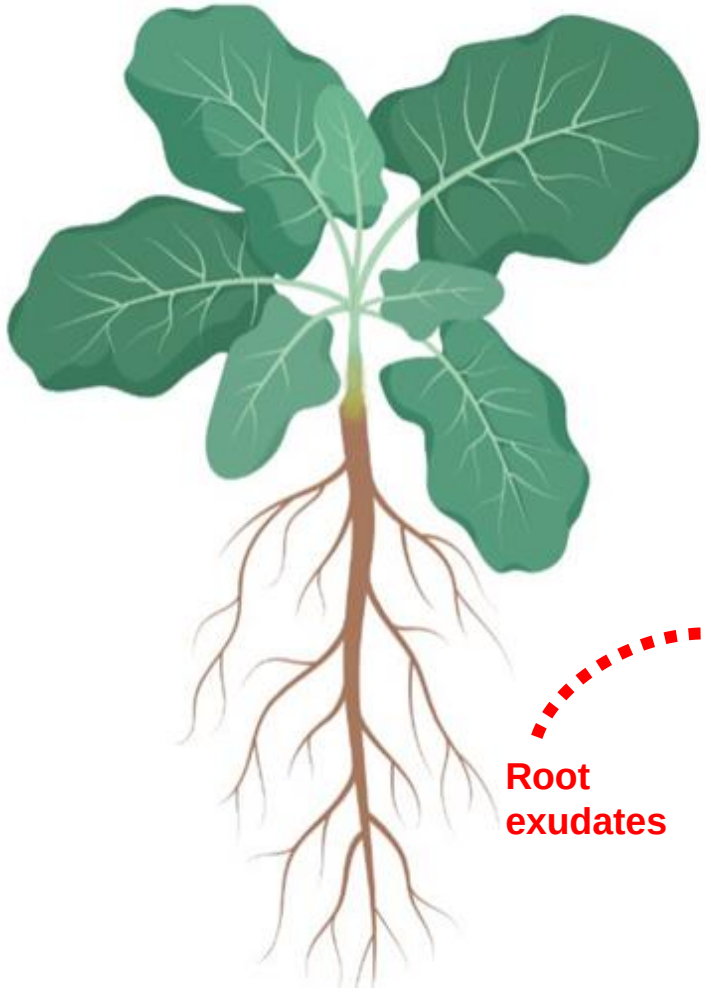
Germination

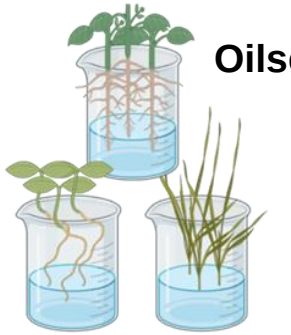
Root infection

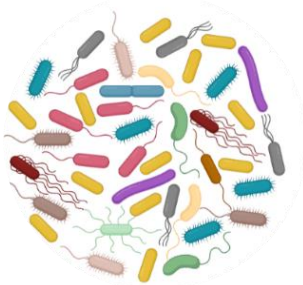
S. Sarenqimuge

❖ Root exudates offset bacterial suppression of microsclerotia germination and enable root infection

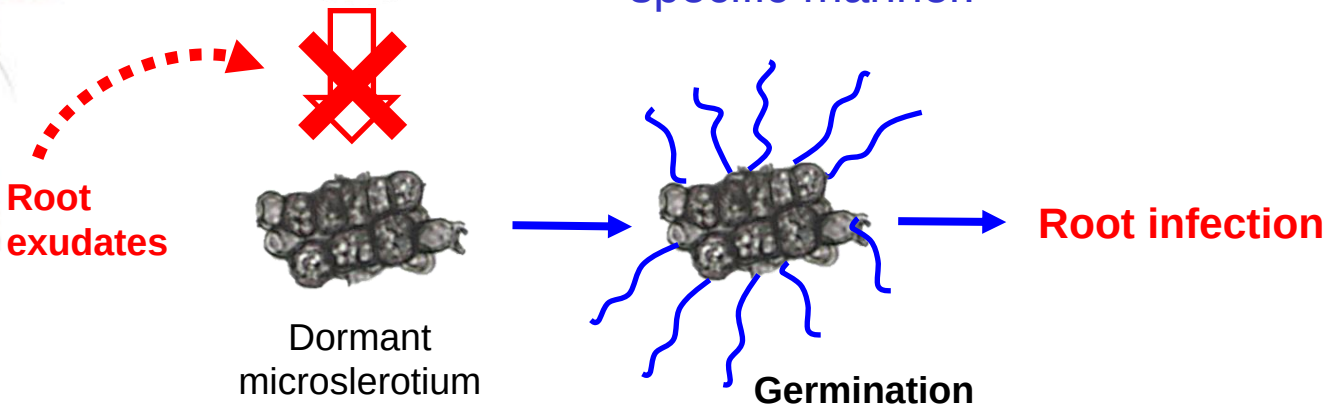
Verticillium longisporum







❖ Root exudates **suppress emission of volatile fatty acids** by soil bacteria, in a non-host specific manner.

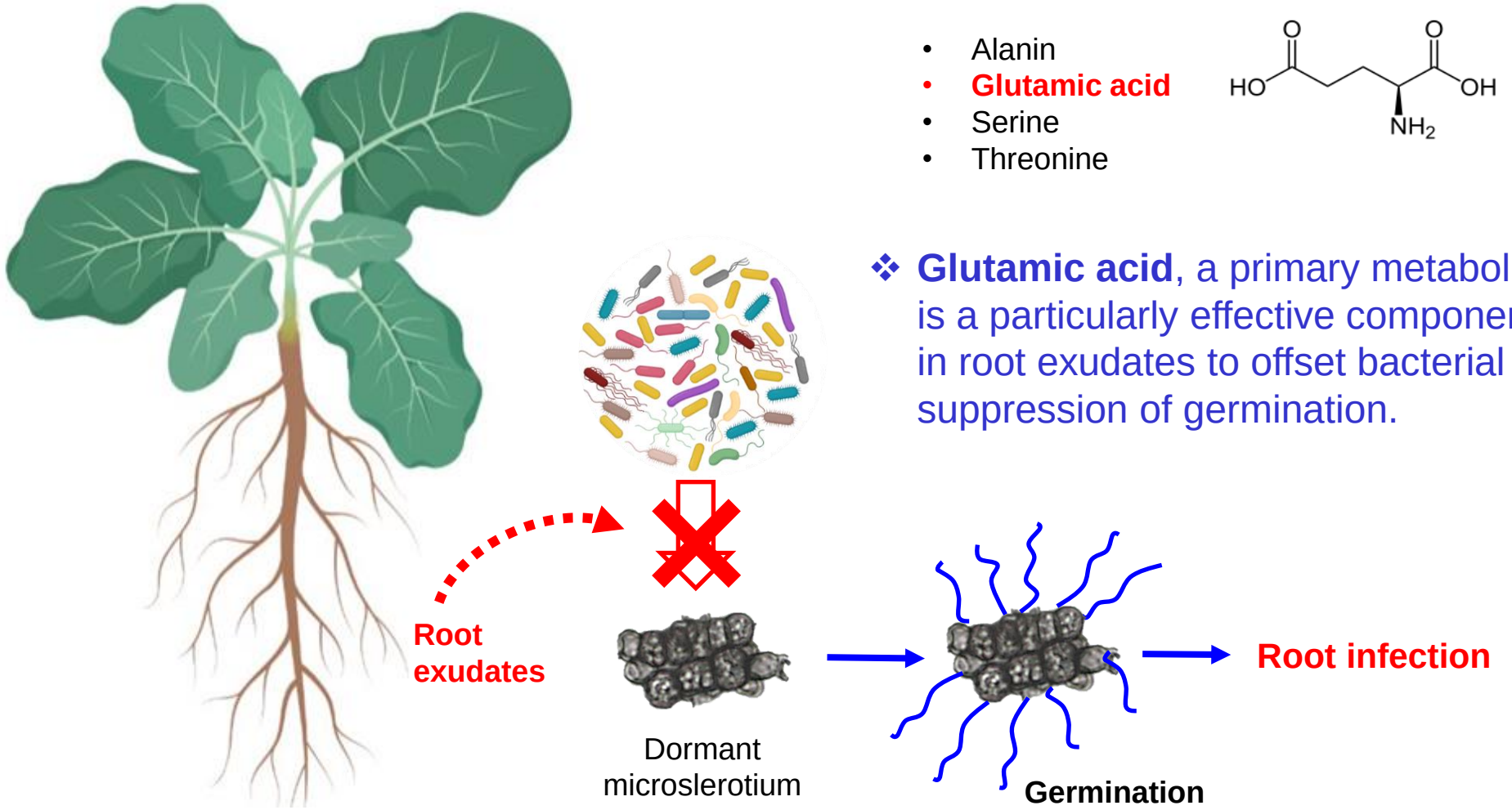


Sarenqimuge, S. *et al*., *Front Microbiol*, 2022

S. Sarenqimuge

❖ Root exudates offset bacterial suppression of microsclerotia germination and enable root infection

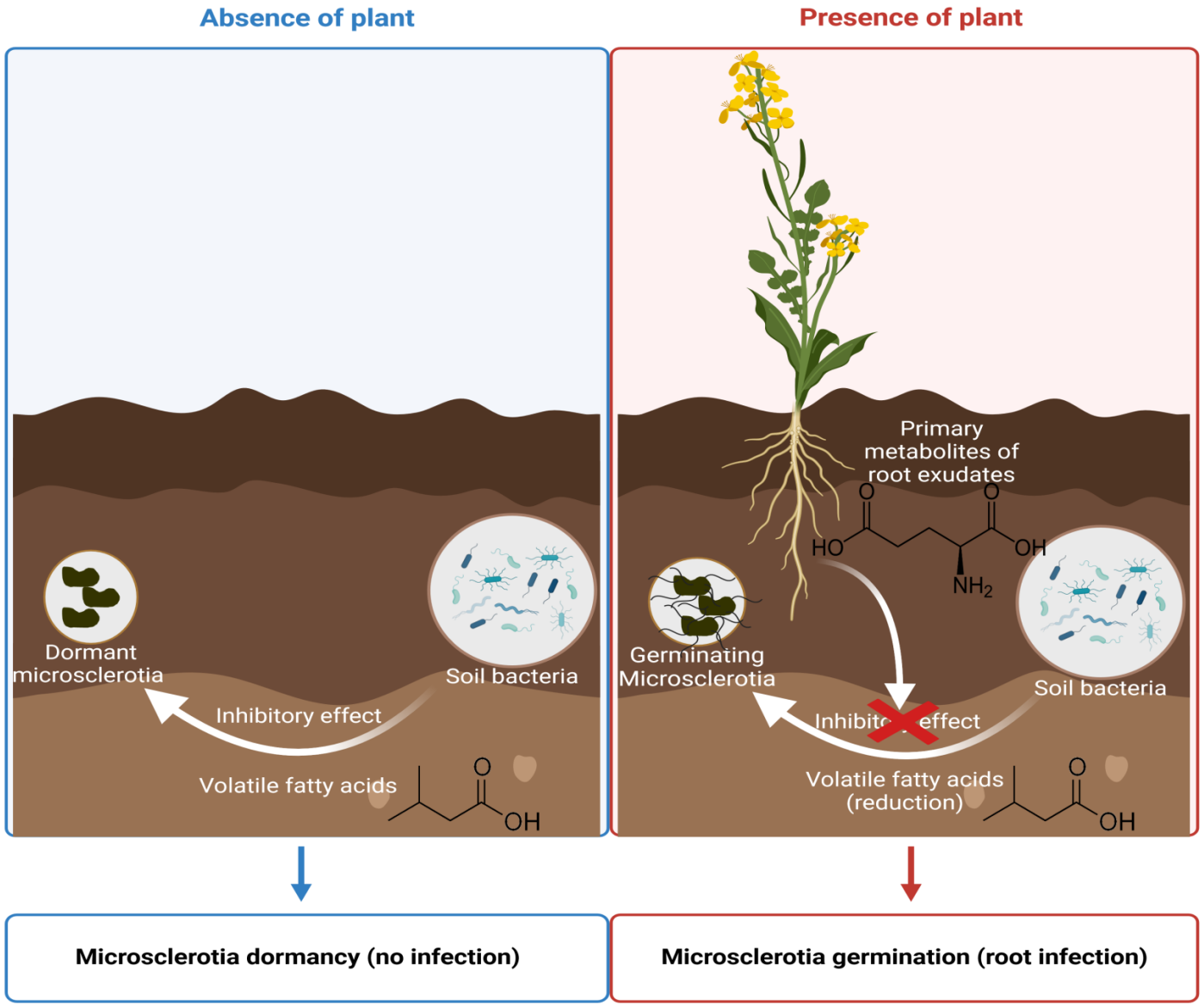
Verticillium longisporum



- Alanin
- **Glutamic acid**
- Serine
- Threonine

❖ **Glutamic acid**, a primary metabolite, is a particularly effective component in root exudates to offset bacterial suppression of germination.

Sarenqimuge, S. *et al*., *Front Microbiol*, 2022

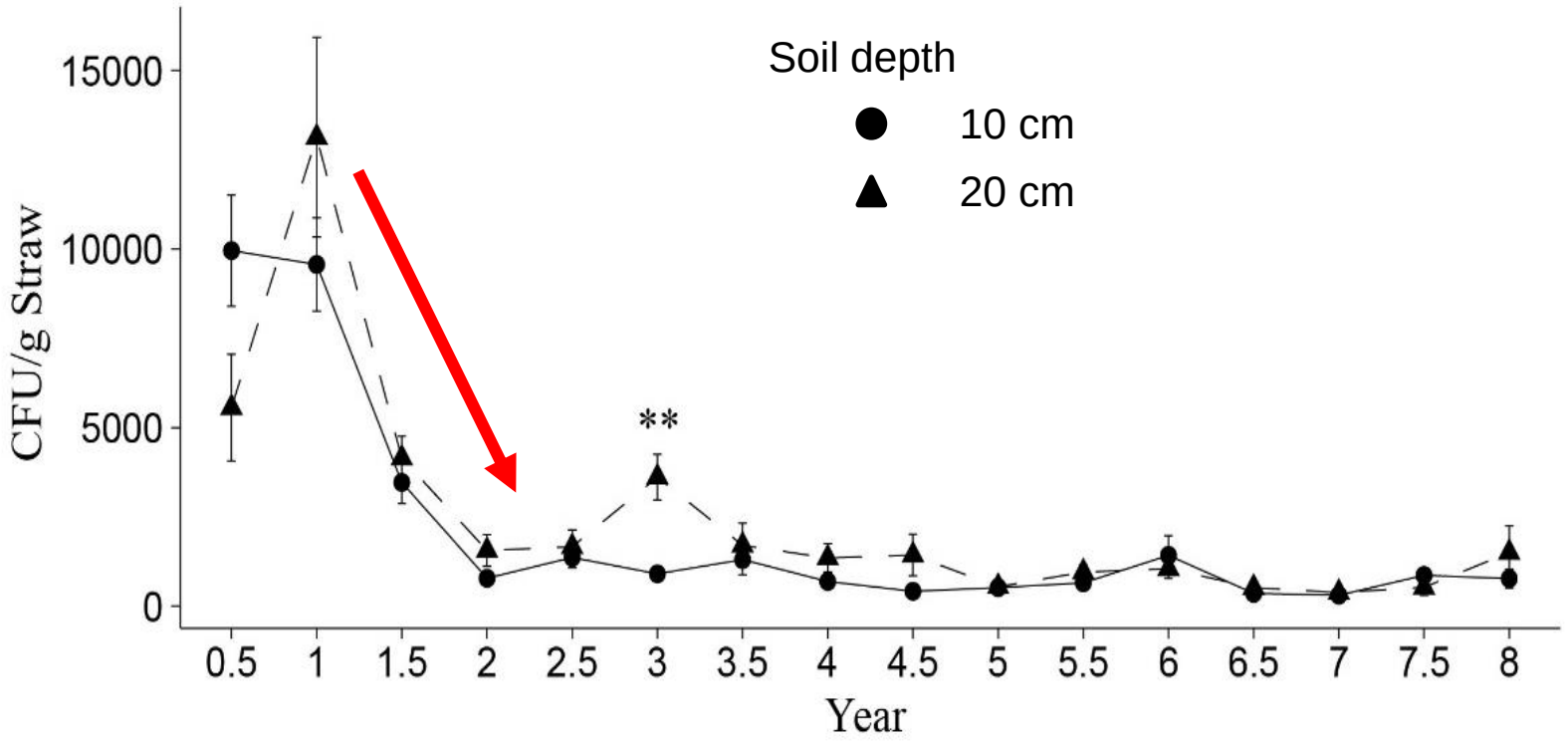


Conclusions

- Suppression of microsclerotia germination by soil bacteria is offset by amino acids secreted from plant roots.
- This mechanism is unrelated to the plant species and not host-specific
  → *any root exudates may induce ms germination!*

Degradation of VL microsclerotia in soil

8-year miniplot field experiment, Göttingen, 2016 - 2024

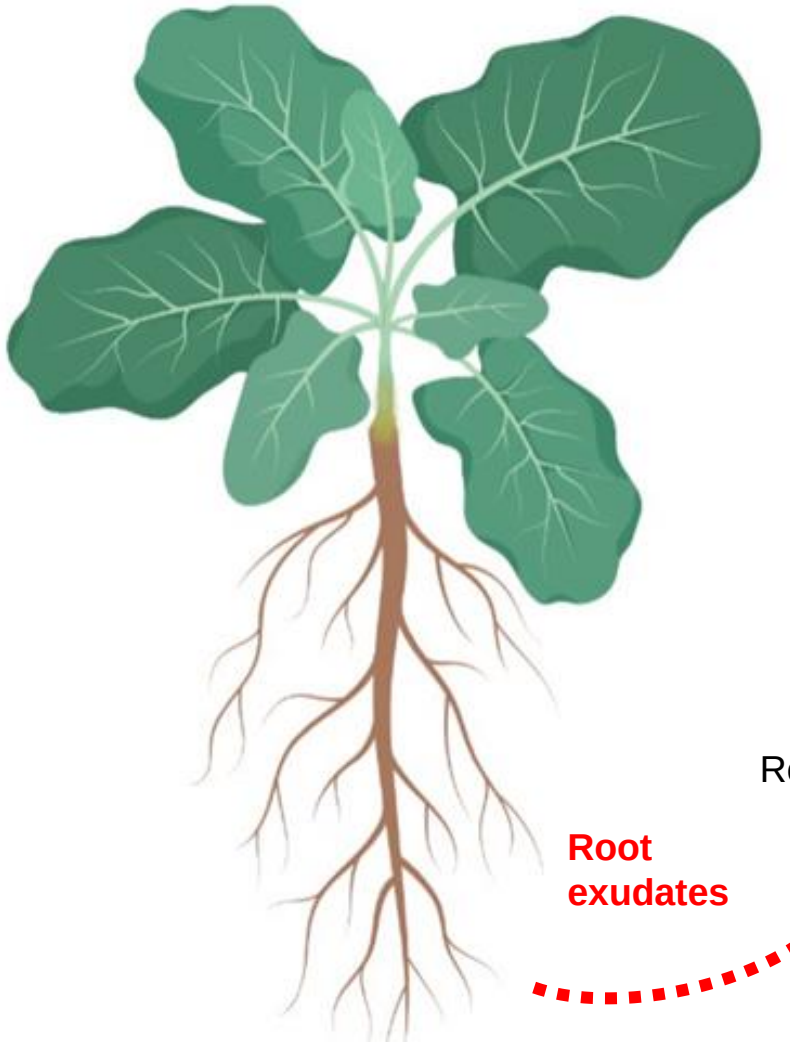


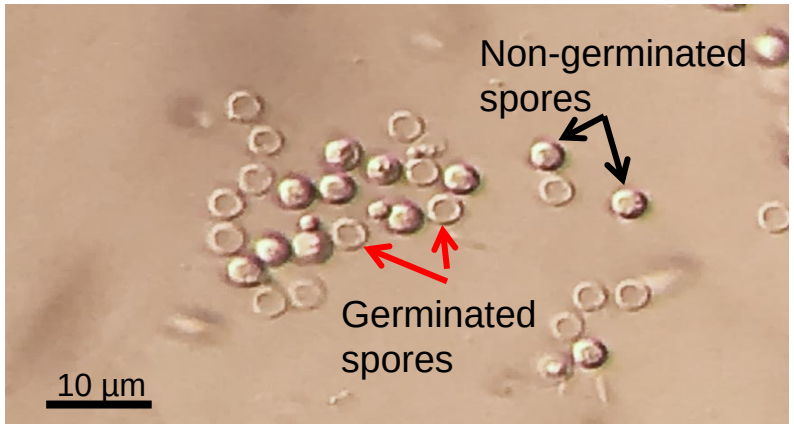
Accepted in *Applied Soil Ecology, 2025*

Club root

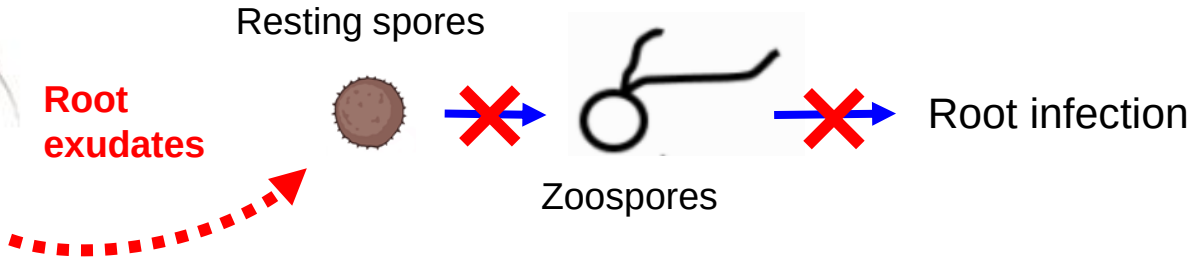
Yao Wang

Club root
Plasmodiophora brassicae





- In sterile conditions, root exudates cannot not induce germination of resting spores.

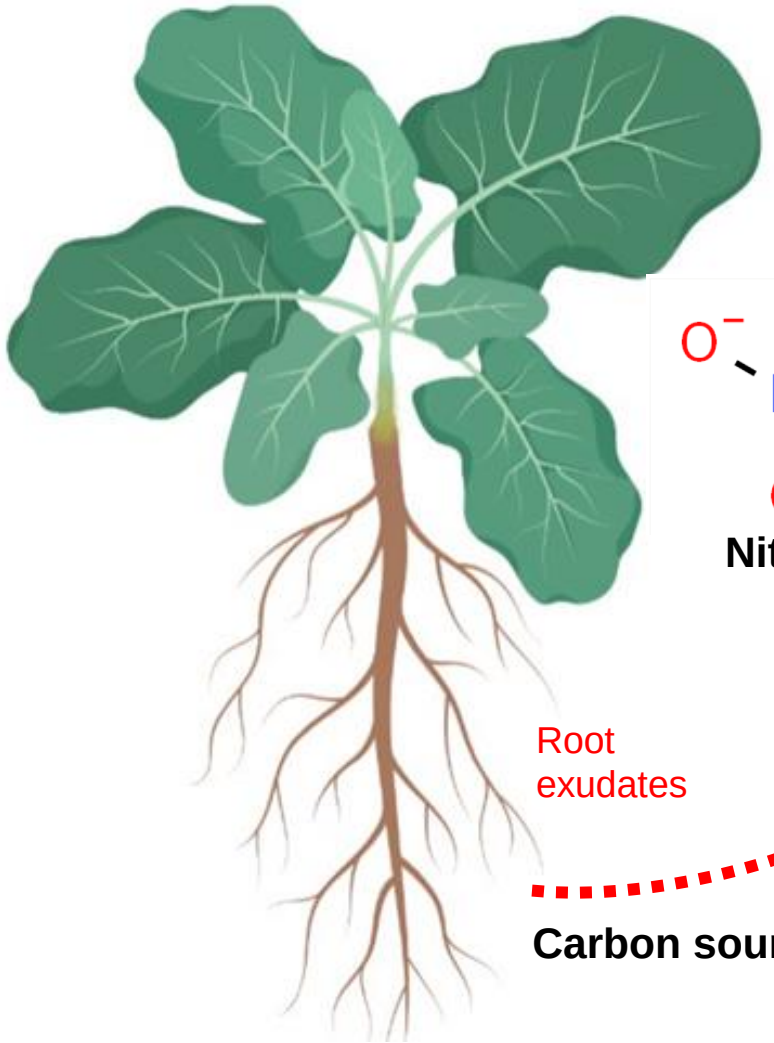


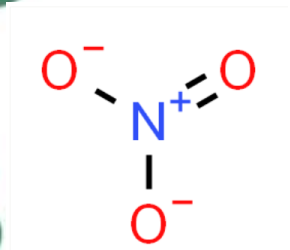
Wang, Y. et al (2022) *Front. Microbiol.* 12:823051

Club root

Yao Wang

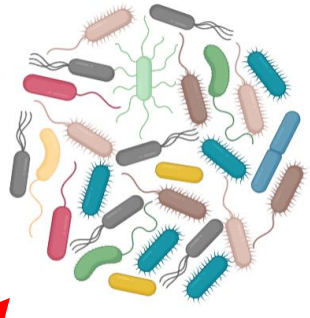
Club root
Plasmodiophora brassicae





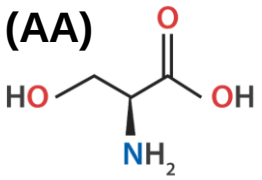
Nitrate

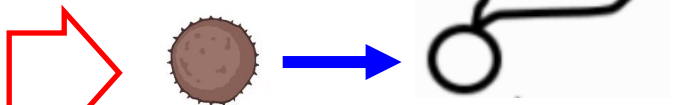
Root exudates



Soil bacteria

Carbon source (AA)





P. brassicae resting spores germinating

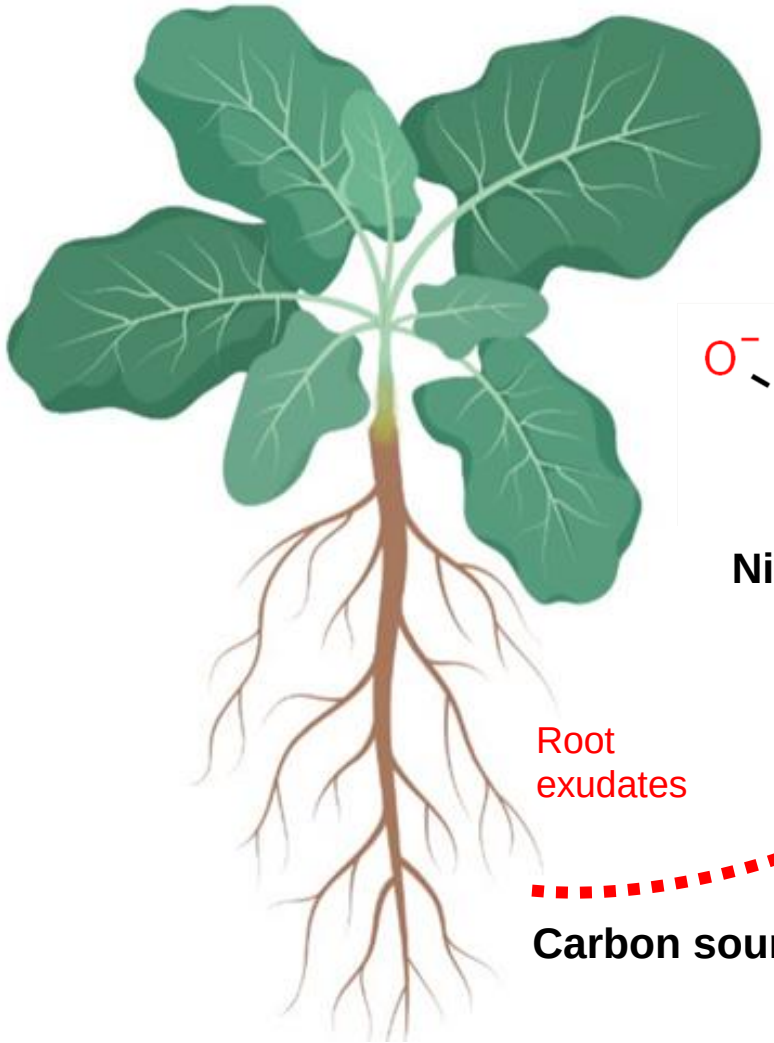
✓

Wang, Y. et al (2022) *Front. Microbiol.* 12:823051

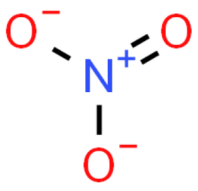
Club root

Yao Wang

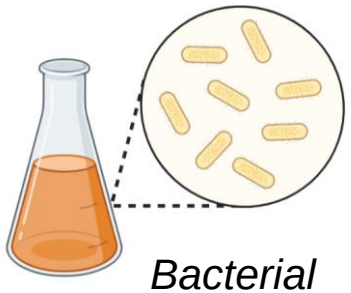
Club root
Plasmodiophora brassicae



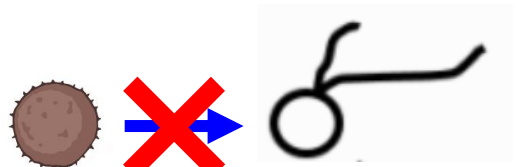
- **Viable soil bacteria**, **nitrate** and a **carbon source** are required to stimulate germination.



Nitrate



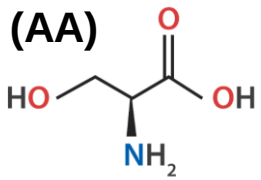
Bacterial culture filtrate



P. brassicae resting spores **not** germinating

Root exudates

Carbon source (AA)

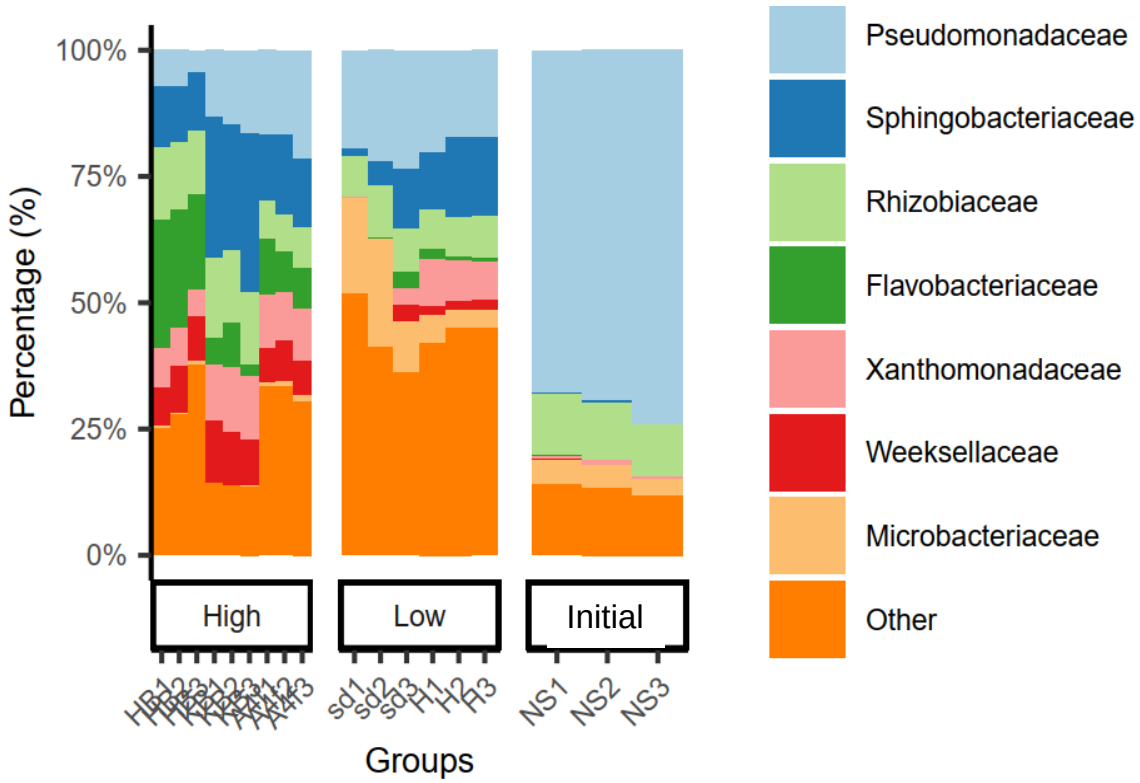


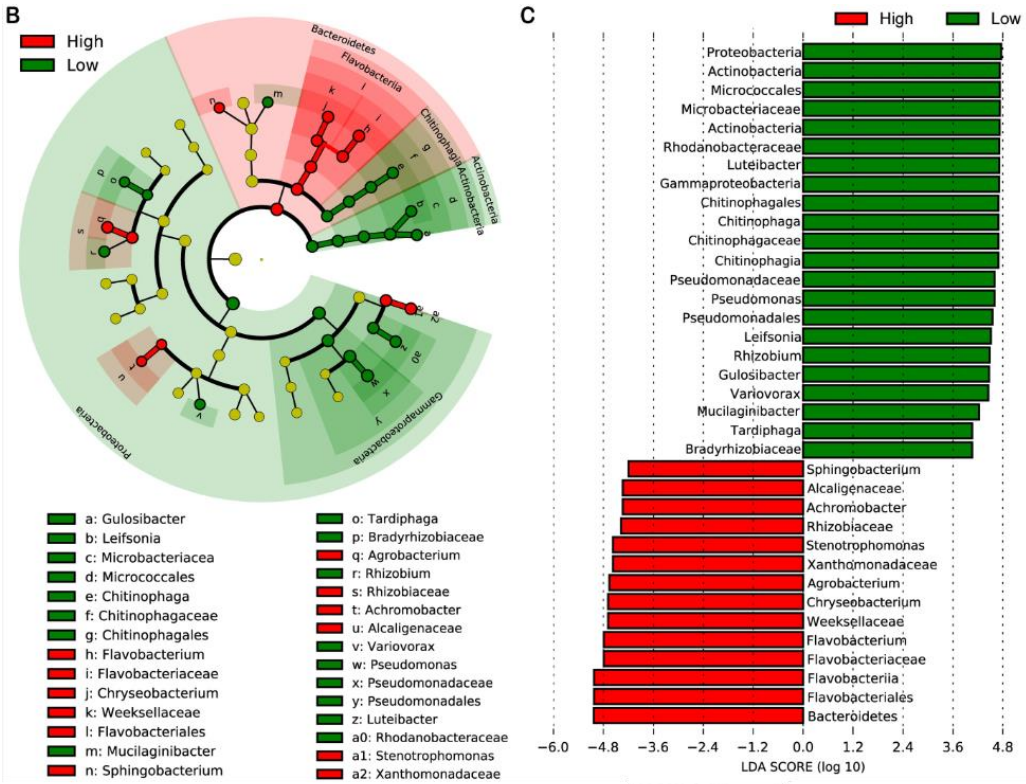
Wang, Y. et al (2022) *Front. Microbiol.* 12:823051

Yao Wang

❖ Bacterial communities differ at high/low germination conditions

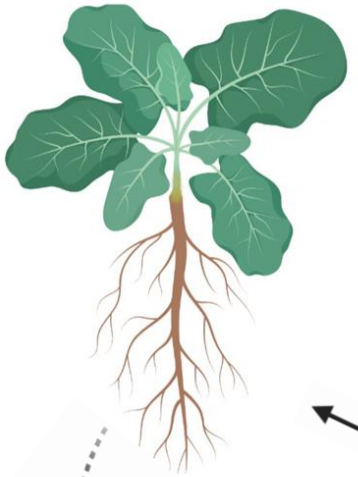
16S rRNA gene amplification and sequencing





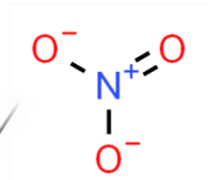
Wang, Y. et al (2023) *PLOS Pathogens* 19(3):e1011175

A pathobiome model for the regulation of germination of *P. brassicae* resting spores

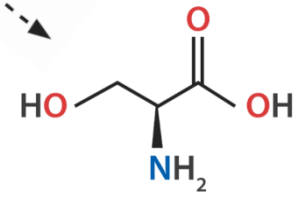


❖ In the presence of **root exudates** (AA Asn, Pro, Ser) and **nitrate**, the **initial bacterial community** is shifted to a **stimulating community**, enriched by several bacterial taxa.

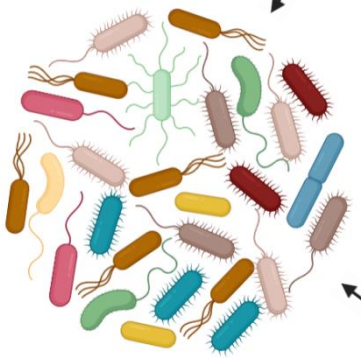
Non-sterile conditions



Nitrate

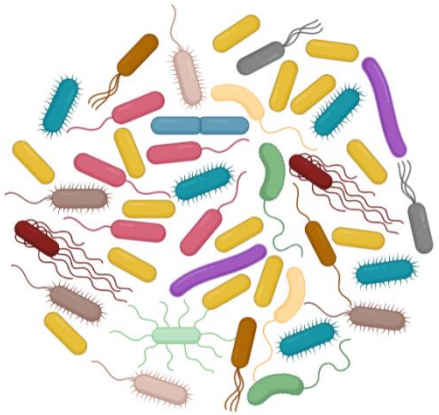


Carbon sources



Initial bacterial community

Soil moisture



Stimulating community

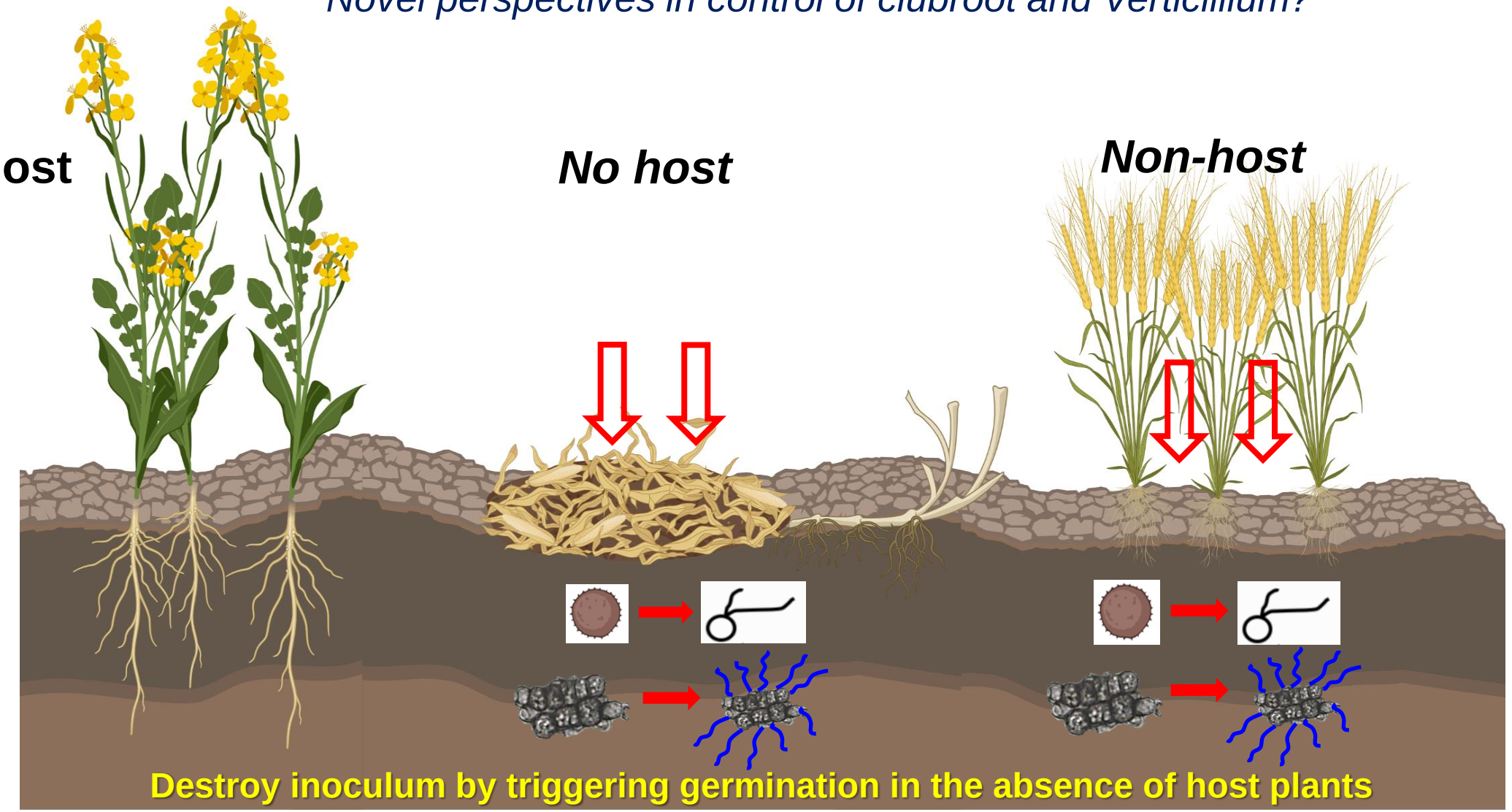
P. brassicae resting spores ✓

Wang, Y. et al (2023) *PLOS Pathogens* 19(3):e1011175

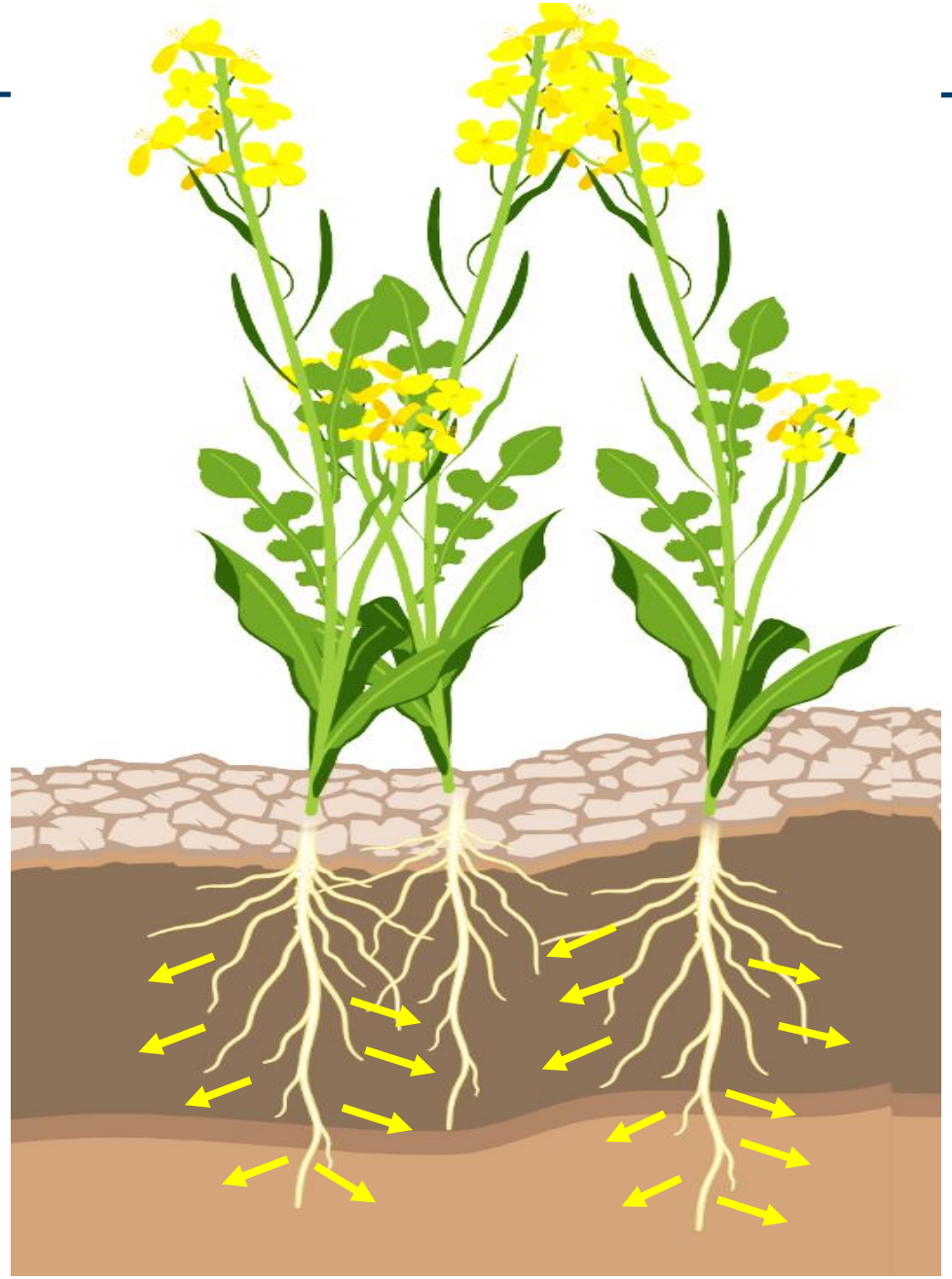
Main conclusions

- Dormancy and germination of soilborne inoculum of Verticillium and clubroot is differentially regulated by multiple factors.
- In none of the two diseases, root exudates are neither the sole trigger of inoculum germination, nor do they determine host specificity.
- In both systems, the bacterial microbiome in the soil plays an essential role, either as suppressor or inducer of germination.

Novel perspectives in control of clubroot and Verticillium?



*Novel perspectives in control of **Verticillium**?*



Can genotypes be selected with less **glutamic acid** root exudation? ?

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Oilseed rape pathology group (since 2002)

Andreas von Tiedemann

BSc- & MSc students

Eiko Tjaden, Fluture Novakazi, Sarah Bartsch, Alice B. Eseola, Leo Sundermann, Laxman Khatri, Saad Khan, Balint Bakondi, Jingjing Yang, Carla Mota Leal, Imke Krohne, Greeshma Govidan, Christian Mahrt, Johannes Brandt, Olufadekemi Fajesim, Kai Howind, Thies Schmoldt, Mohammad Farooq, Coretta Klöppel, Siv Ahlers, Leif Horak, Ruben Gödecke, Katharina Müller, Ulrike Krause, Daoud Ibrahim, Rafiqul Islam, Jan Utermark, Thees Rewerts ….

PhD students

Sarah Dunker Christine Eynck

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