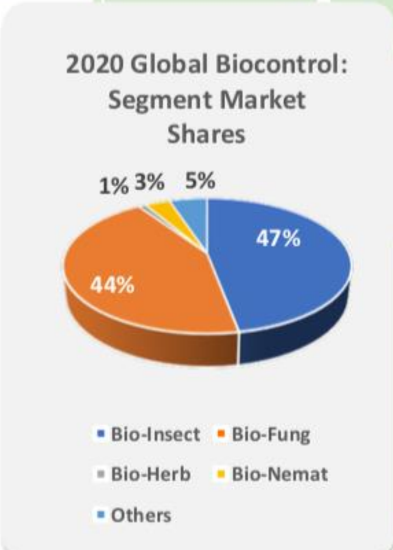
L'utilisation de micro-organismes en agriculture pour la biostimulation et le biocontrôle

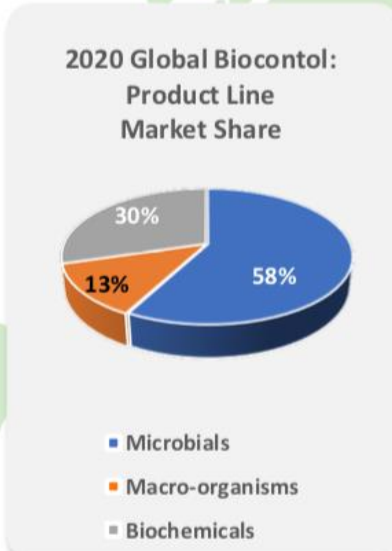
Philippe Jacques, Marc Ongena

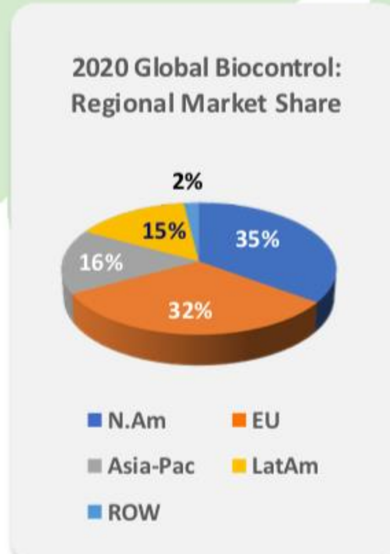
University of Liège, Joint Cross-Border Research Unit BioEcoAgro, TERRA Teaching and Research center, Gembloux Agro-Bio Tech, MiPI Lab, Avenue de la Faculté, 5030 Gembloux, Belgium

Journée clôture Projet MISS, 28 Février 2024, LLN

BioProducts on the phytosanitory market: Global Landscape







Product lines:

- Microbials growing faster as both small and large companies invest in microbial discovery and development

- All product segments growing much faster than the traditional crop protection market

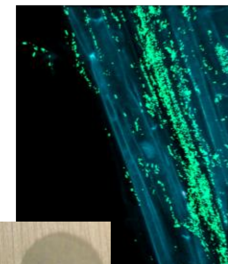
- Microbials will continue to make up nearly 60% of total market through 2025

Plant-beneficial rhizobacteria: multiple benefits

Growth promotion, yield increase

<u>Protection against phytopathogens, disease resistance</u>

- Good root colonizers
  > competition for space and ressources
- Strong antagonists
  > direct inhibition of phytopathogens
- Efficient triggers of host immunization
  > systemic resistance

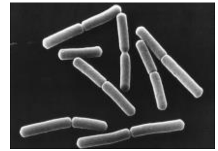


Control

Treated

Bacillus as biocontrol agents

B. velezensis as prototype species of plant-associated and plant-beneficial bacilli



Technological advantages:

"Generally Recognized As Safe"

Well-studied microbes

Aerobic, fast growing

Low nutritional requirements

Form spores

Efficacy:

Disease protection in field/ind. greenhouse

Rhizosphere competence and soil persistence

Acts via competition, antagonism and ISR

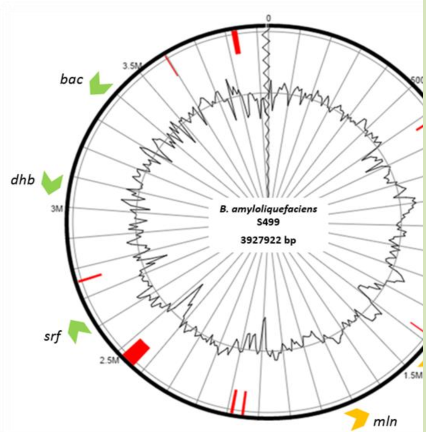
> Bioactive/biocontrol Secondary Metabolites (BSMs)

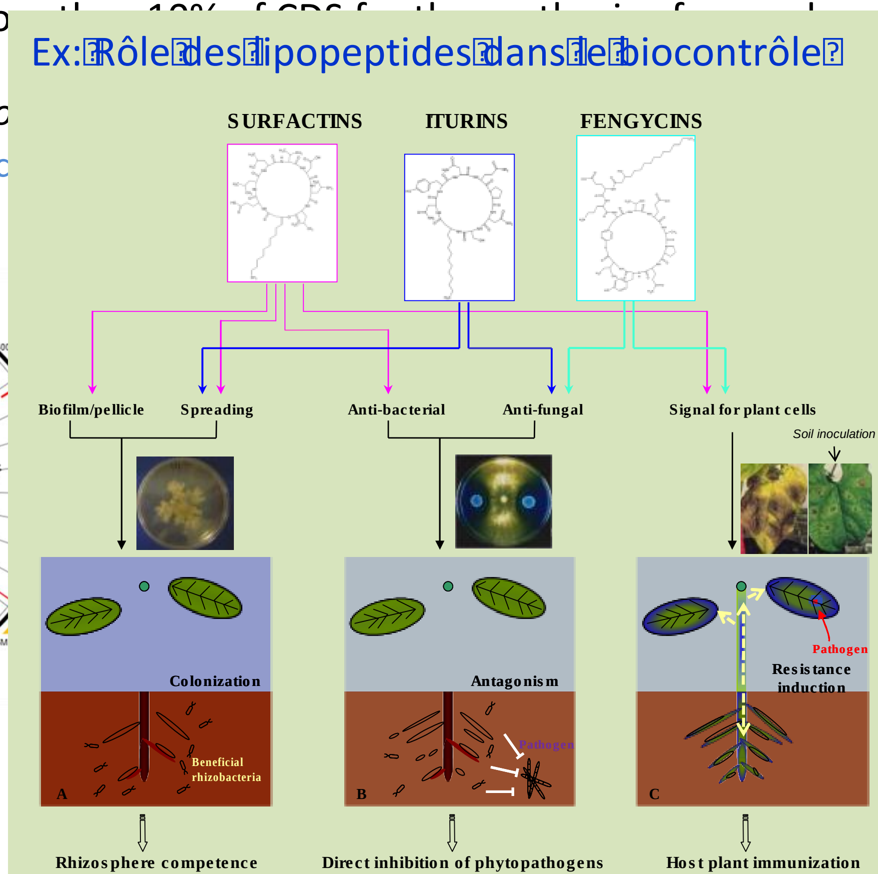
BSM chemodiversity in *B. velezensis*

Genomic richness, mo
metabolites

Siderc

Bac





tins A-M
nyl
inyl

/F/L/Lc

Orphan gene clusters (NRPS, terpenes)
> cryptic BSMs

Bacilysin
Kijanimicin-like

Ericins
Mersacidin

Strong potential for some bacteria as biocontrol products but still limitations due to low and inconsistent efficacy in the field

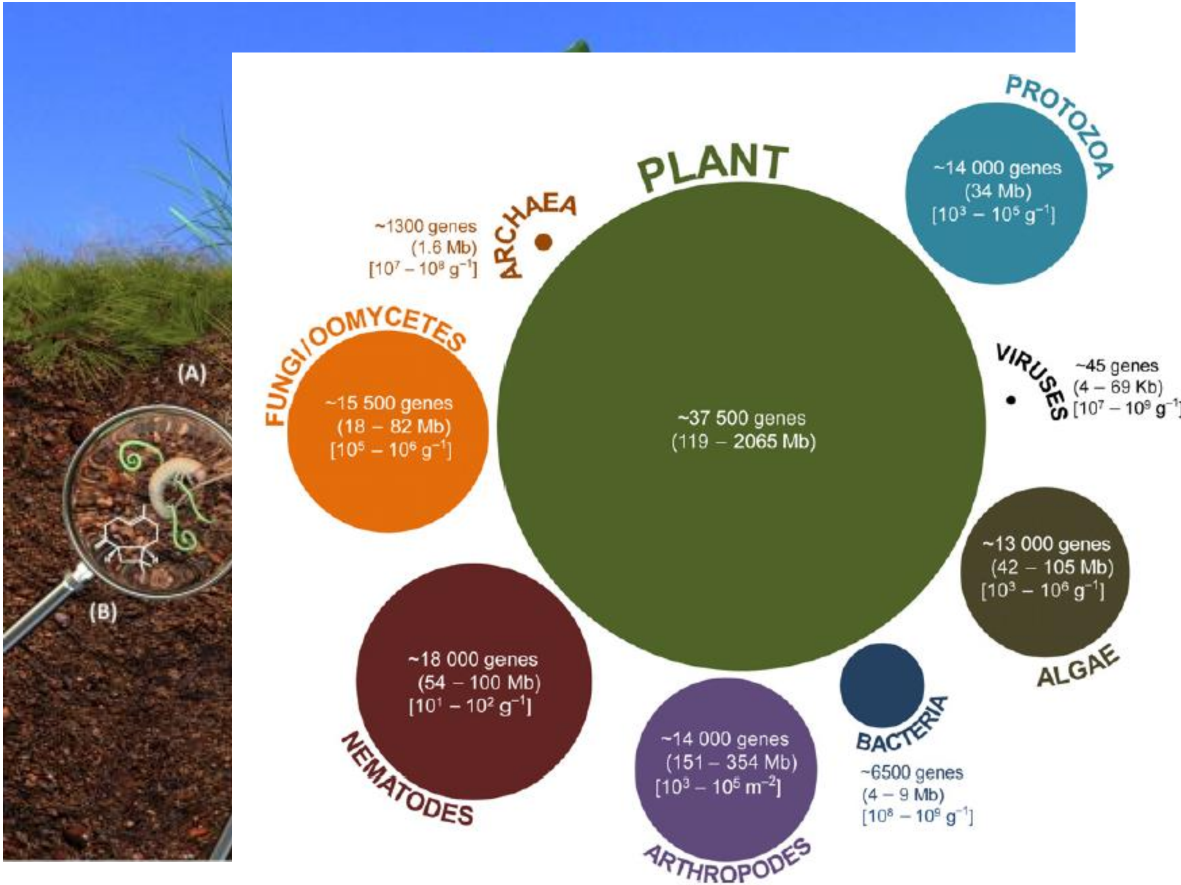
Main cause of failure:

Adverse abiotic conditions AND **biotic interactions**
⇒ poor fitness/persistence in the niche after application

Multitrophic factors influencing PBR in the soil

- Soil pH
- Organic carbon quality and quantity
- Soil $[O_2]$ and redox status
- Soil moisture availability
- Nitrogen and phosphorus availability
- Soil texture and structure
- Temperature
- Plant, molecular interactions
- Predation, virus lysis
- Other microbes, competition
- Sessile, slow-growing lifestyle

Microbial interactions in the soil context



Improving our knowledge… to improve efficacy

How *B. velezensis* behaves in its habitat regarding both physiology and expression of BSMs?

↓

Rhizosphere ecological functions:

Establishment and colonization of roots

Competition with other microbes sharing the niche > antimicrobial

Molecular dialogue with/tolerance by the host plant (good partner!)

→

Biocontrol-related activities:

Competition for space and nutriments

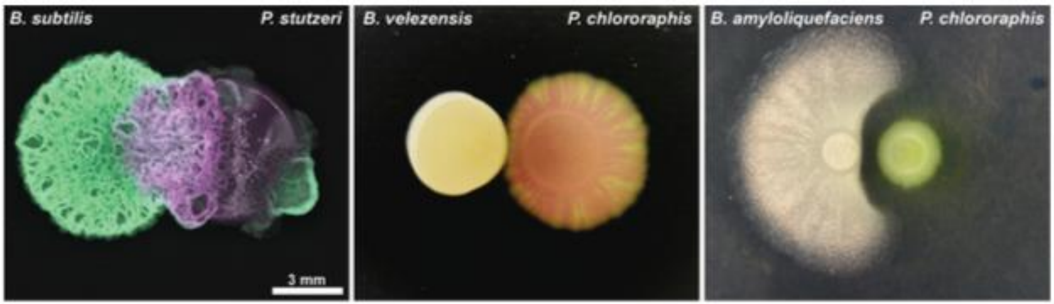
Direct inhibition of phytopathogens

Priming of plant immunity (systemic resistance, ISR)

↓

Understanding and exploiting microbial interspecies interactions

Bacillus vs other bacteria: interspecies interactions

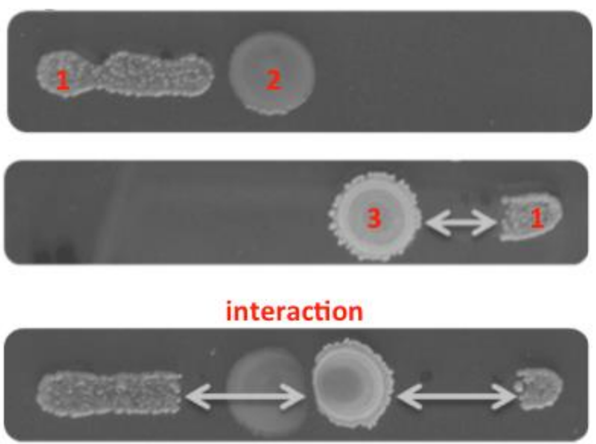


Different outcomes:

Mutualistic (cooperative), neutral, competitive

Bacillus-Pseudomonas

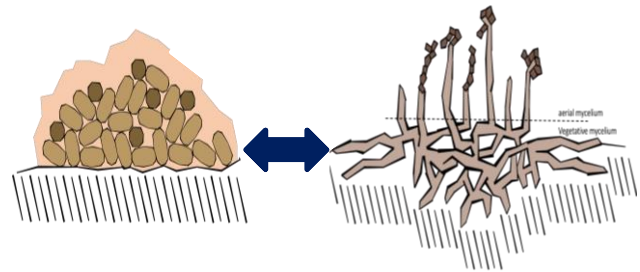
The perception of secreted soluble *Pseudomonas* compounds boost antibacterial activity *of Bacillus velezensis* against both G+ like *Clavibacter michiganensis* and G- like *Xanthomonas campestris*

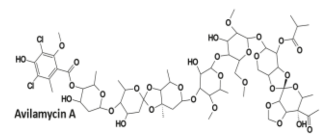


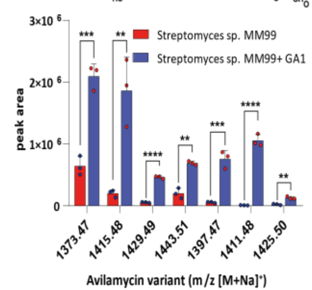
1. *C. michiganensis* subsp. *michiganensis*
2. *Pseudomonas* sp.
3. *B. velezensis*

Bacillus-Streptomyces

The perception of *Bacillus* signals boost the production of new antibiotics in *Streptomyces venezuelae*

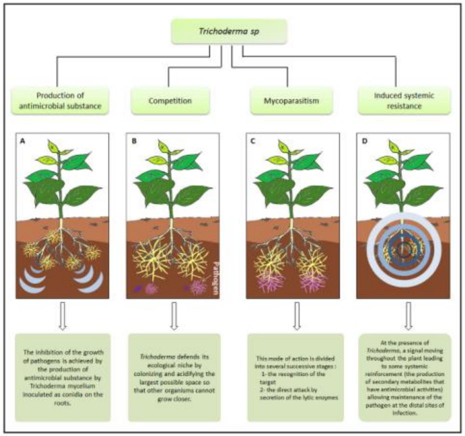


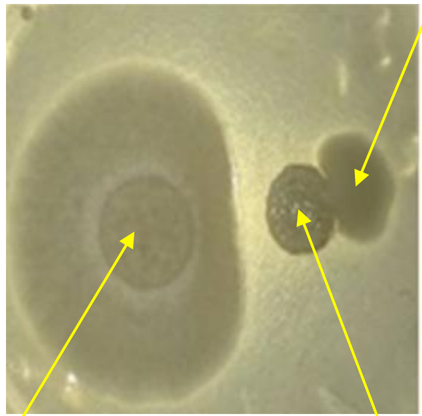


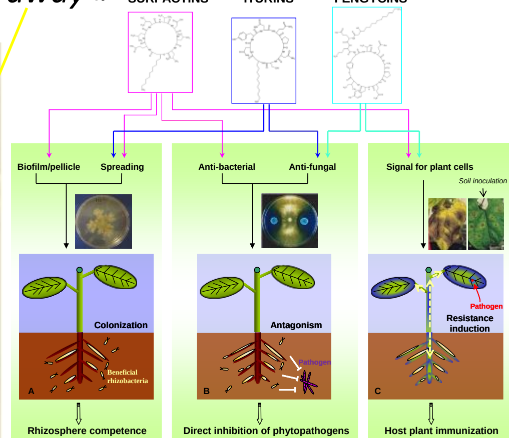


Trichoderma et *Bacillus velezensis*, sont-ils compatibles ?

« *Fly away* »







Trichoderma

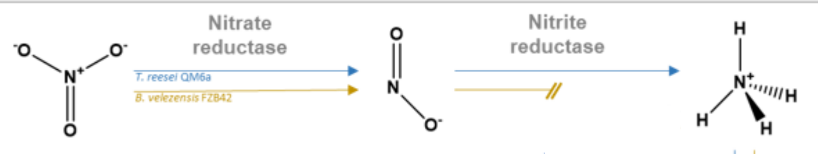
Fifani et al., 2022, Microorganisms

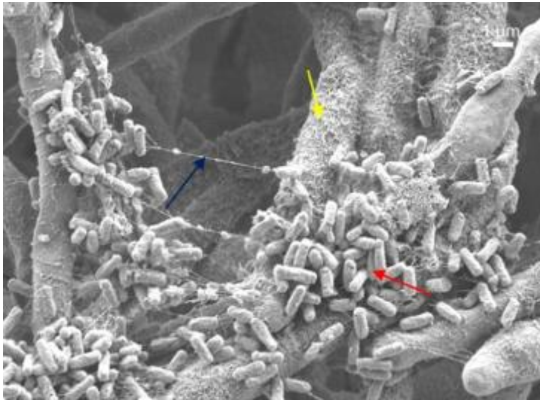
Bacillus

En présence de nitrate ou de nitrite comme seule source d'azote, une co-culture est possible

Assimilation du nitrate → ***Croissance de Trichoderma*** → **Excrétion d'acides aminés** → **Croissance de *Bacillus***

? → **Répression de l'expression des opérons lipopeptide**





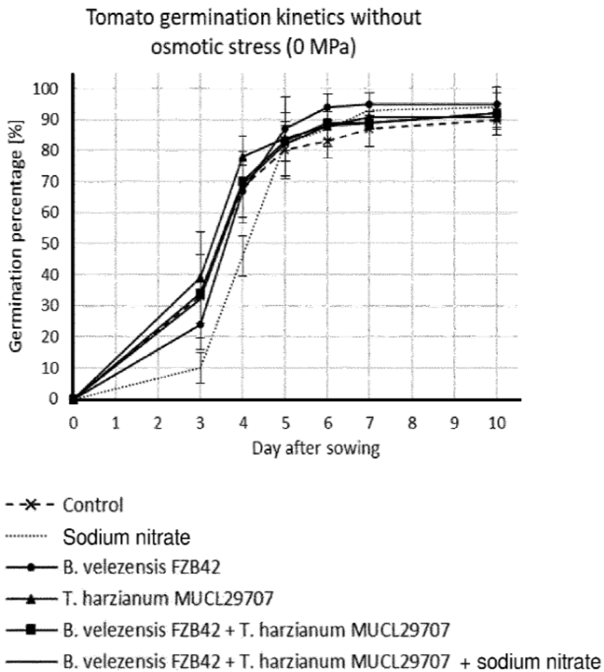
Fifani et al., 2022, Microorganisms

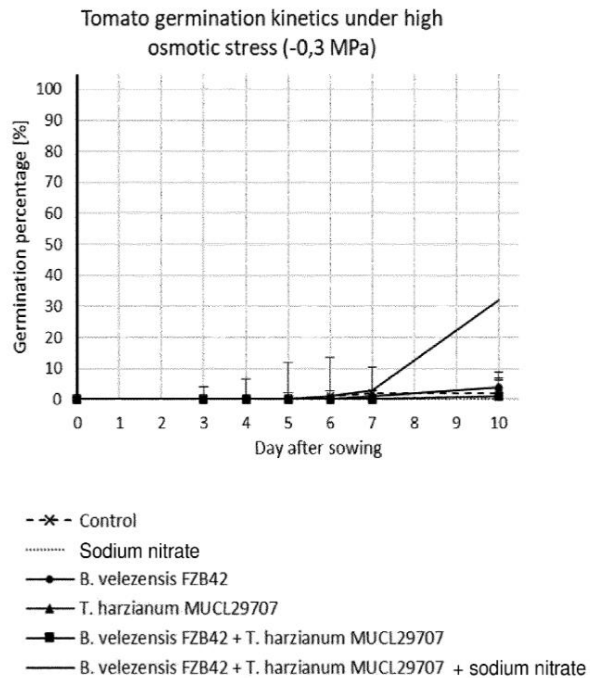
BioEcoAgro

Nouveau brevet ULiège-ULille
PatentWO2022/207940 A1

LIÈGE université Gembloux Agro-Bio Tech

Une nouvelle formulation *Trichoderma-Bacillus*-nitrate favorise la germination des semences de tomates en conditions de stress hydrique





En conclusion…

Efforts en R&D à tous les niveaux indispensables afin de:

- Valoriser au mieux *Bacillus* et d’autres rhizobactéries en tant que produits biologiques pour la biofertilisation et le biocontrôle

- Concevoir des consortia efficaces qui associent rhizobactéries entre elles ou avec d’autres microorganismes

- Développer des produits dont la mtière active est un/des métabolites issus de ces rhizobactéries (ex. lipopeptides)

Biocontrôle 4.0 :
un nouveau portefeuille de projet européen

Gestion et Communication
Trans-Manage
GxABT/ULiège

Développement de biofongicides et biostimulants
Trans-Lipo
URCA

Développement de bioinsecticides
Trans-Pest
UMons

Outils du numérique et de la robotique
Trans-eBio
Multitel

Démonstrateurs en serre et au champ
Trans-Control
PCG

Gestion durable des maladies fongiques du lin
Trans-Pathoflax
Inagro

Formation et Entreprenariat
Trans-Training
ULille

Merci pour votre attention