

# Translating novel results from plant microbiome research into biotechnological applications

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# PROBLEM: Biodiversity loss world-wide



## Anthropocene:

### Human activity and intense agriculture caused:

- ✓ altered biogeochemical cycles
- ✓ Biodiversity loss - 100 to 1,000 times higher than usual
- ✓ Salinated and degraded soils
- ✓ Increasing problems to control pathogens and resistances

## BIODIVERSITY & RESILIENCE LOSS



**Solutions: Microbial Inoculants**



# The Institute of Environmental Biotechnology

## Understanding

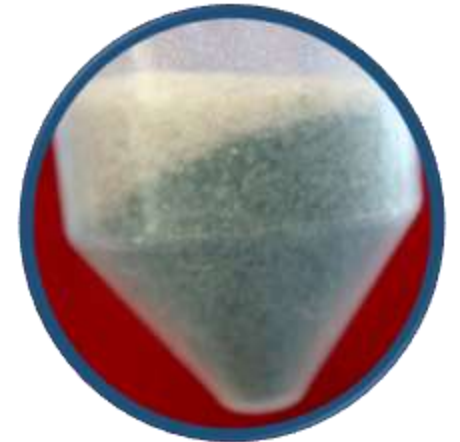
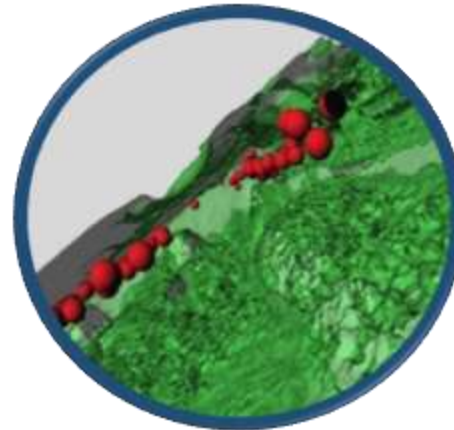
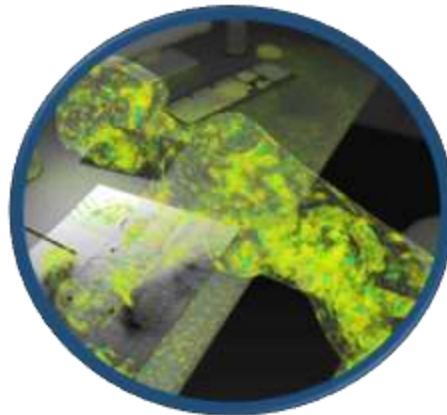
- **Plant microbiome** (Understanding of native and crop plants, endophytes, life cycles)
- **Inter-linked microbiomes** (Plant – build environment, plant – soil, plant – human)
- **Microbiome and plant and human health**



Head  
Prof. Gabriele Berg

## Engineering

- **Microbials** to protect plants against biotic and a-biotic stress
- **Bioactive compounds** (especially volatiles) to control microbiomes
- Formulation technologies for microbials



**Our vision: Microbiome-based solutions for *one* health**







## **Plant microbial diversity**

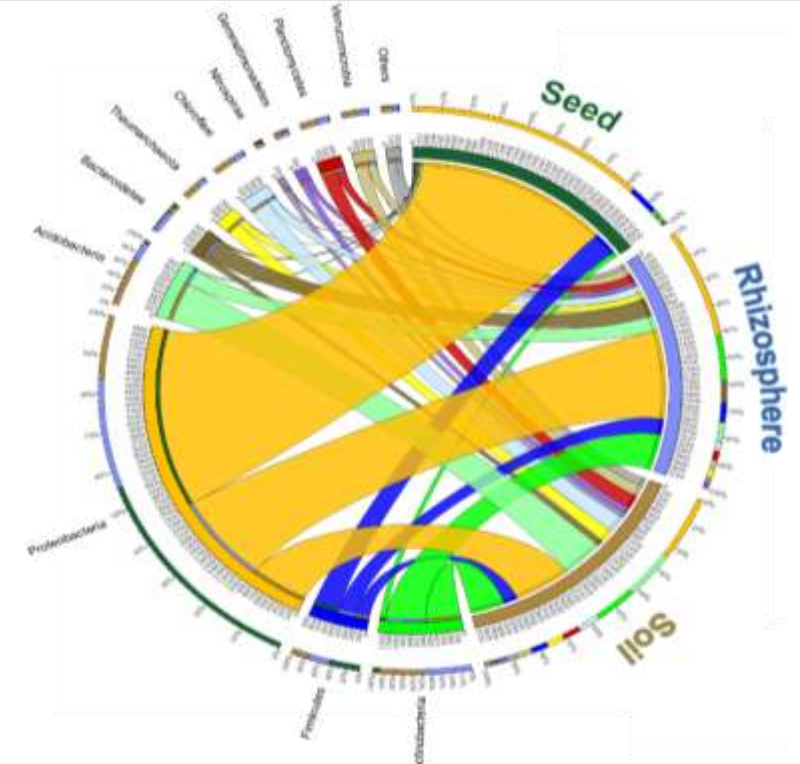
**The seed is an optimal carrier for microbial inoculants**





# 1. Which microbial diversity is associated with pumpkins?

Type	Denomination	Pedigree	Geographic origin	Seed samples
Homozygous inbred lines	Line A - D	-	Austria	
Single cross hybrid	Gleisdorfer Diamant	Line A x Line B	Austria	
Three-way cross hybrids	GL Opal GL Rustikal	Gl. Diamant x Line C Gl. Diamant x Line D	Austria	
Population cultivar	GL Classic	-	Austria	
Single cross zucchini hybrid	Naxos	-	Netherlands	
Segregating breeding lines	Line E – I	-	Germany, Slovenia, China	

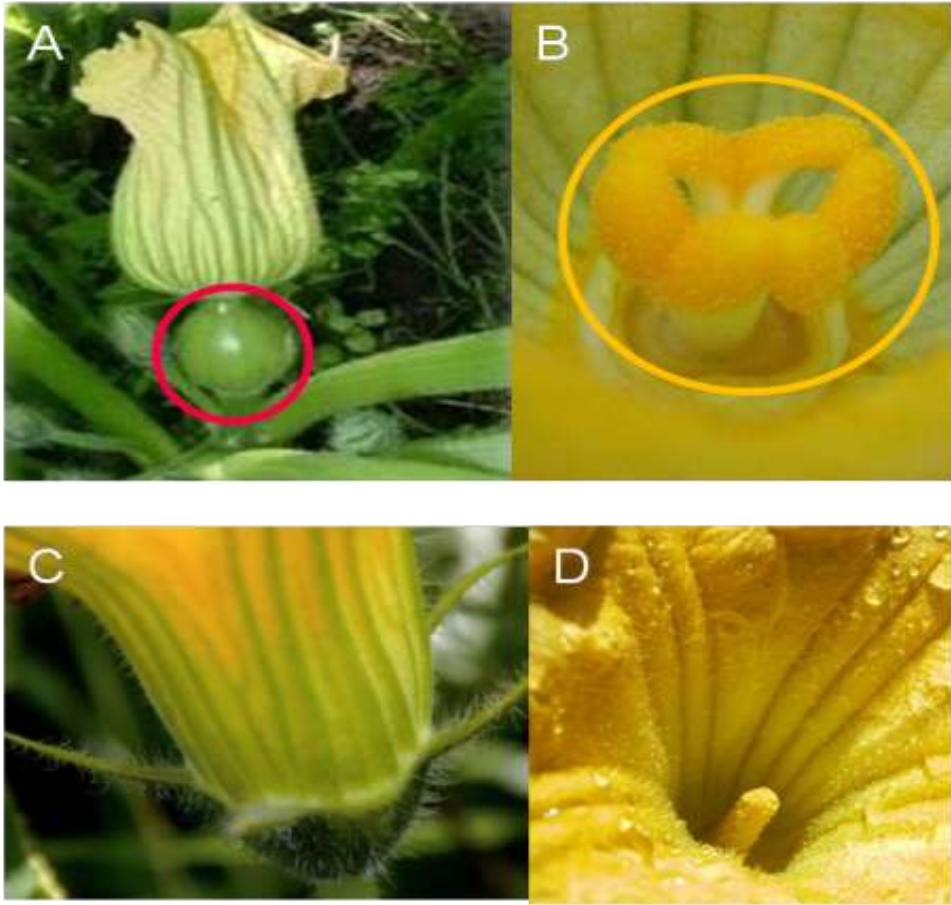


**The microbiome was shaped by breeding**  
**The microbiome correlated with resistance**  
**against *Erwinia carotovora***

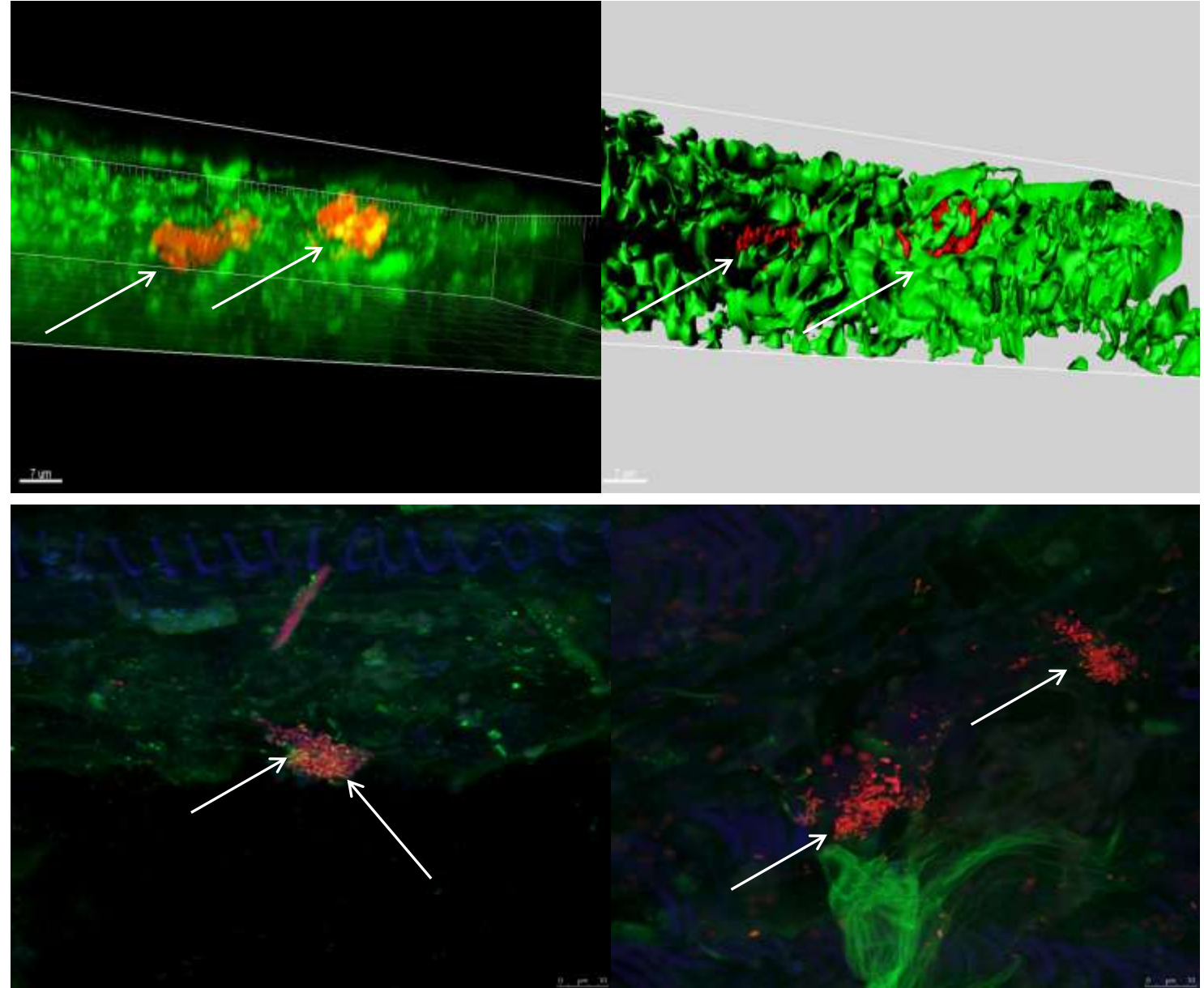
[Adam *et al.* Plant and Soil 2016]



# 1. Which microbial diversity is associated with pumpkins?

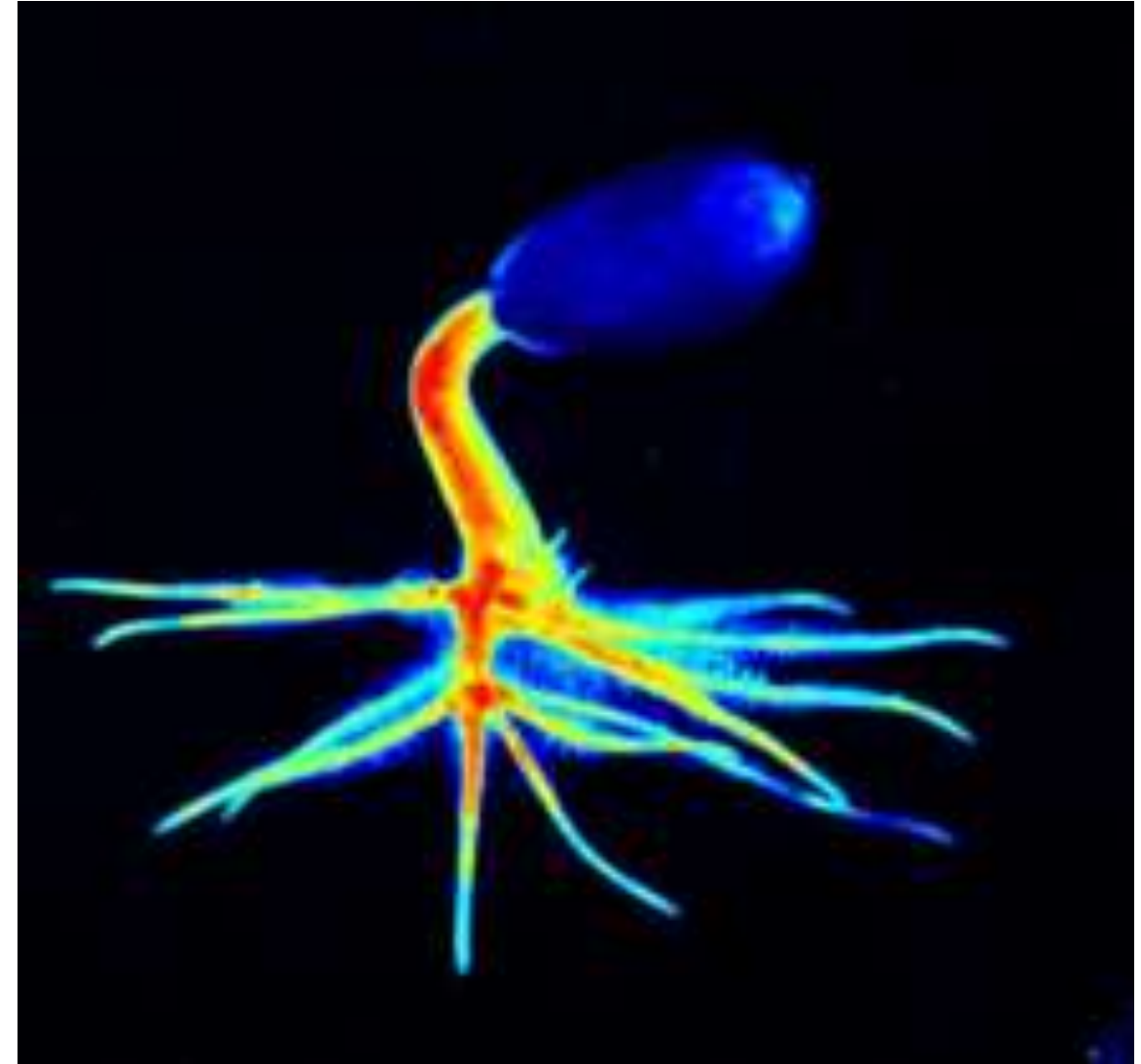
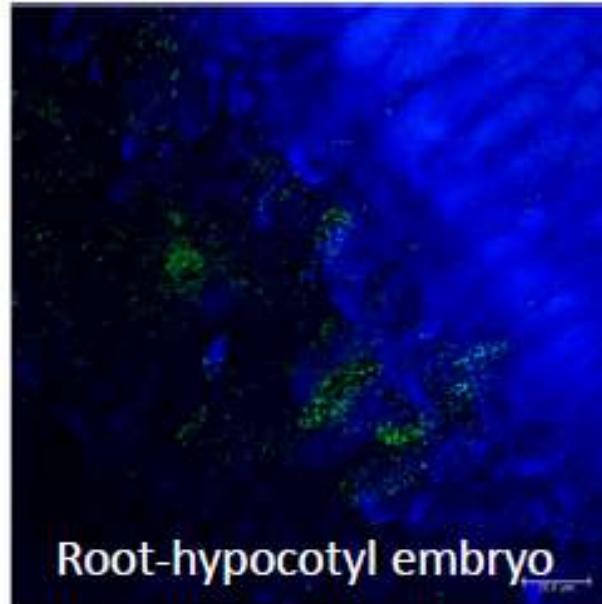
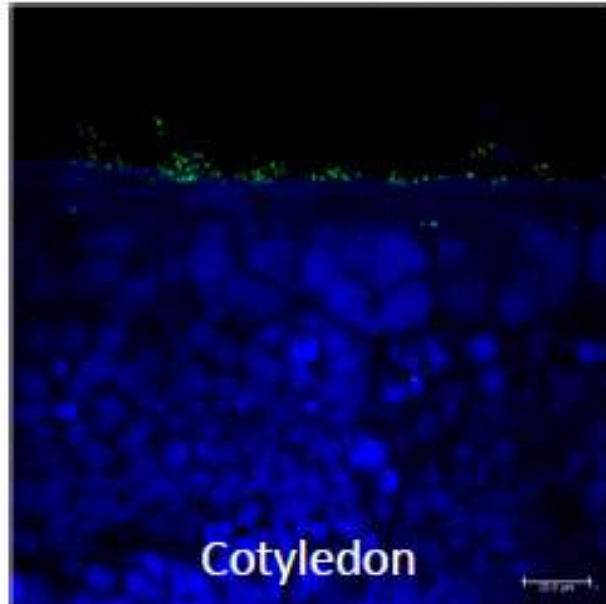
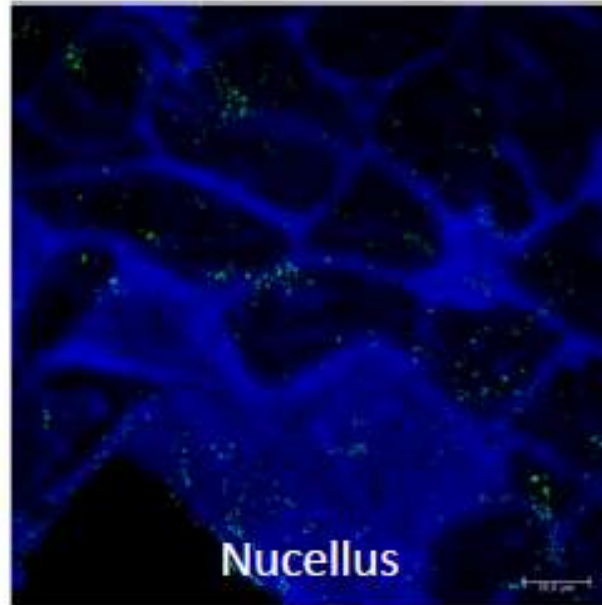
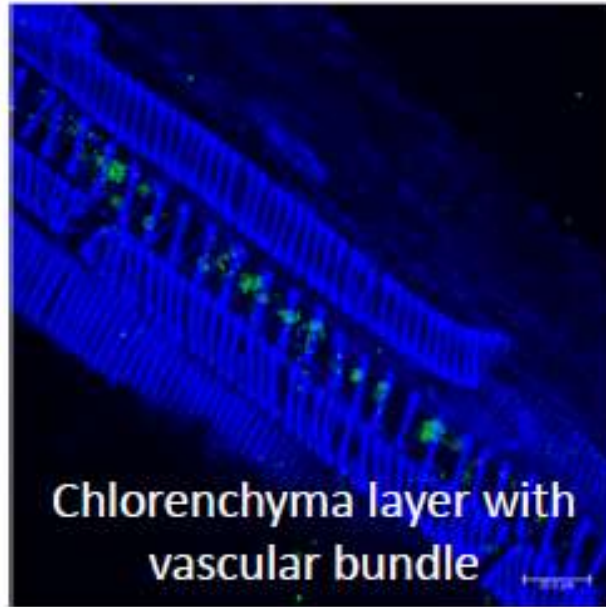


**MATERNAL Microbiota**  
**Bacteria on the petal of the**  
**withered female oil pumpkin**  
**flower visualized by CLSM and**  
**FISH. 3D construction by IMARIS.**

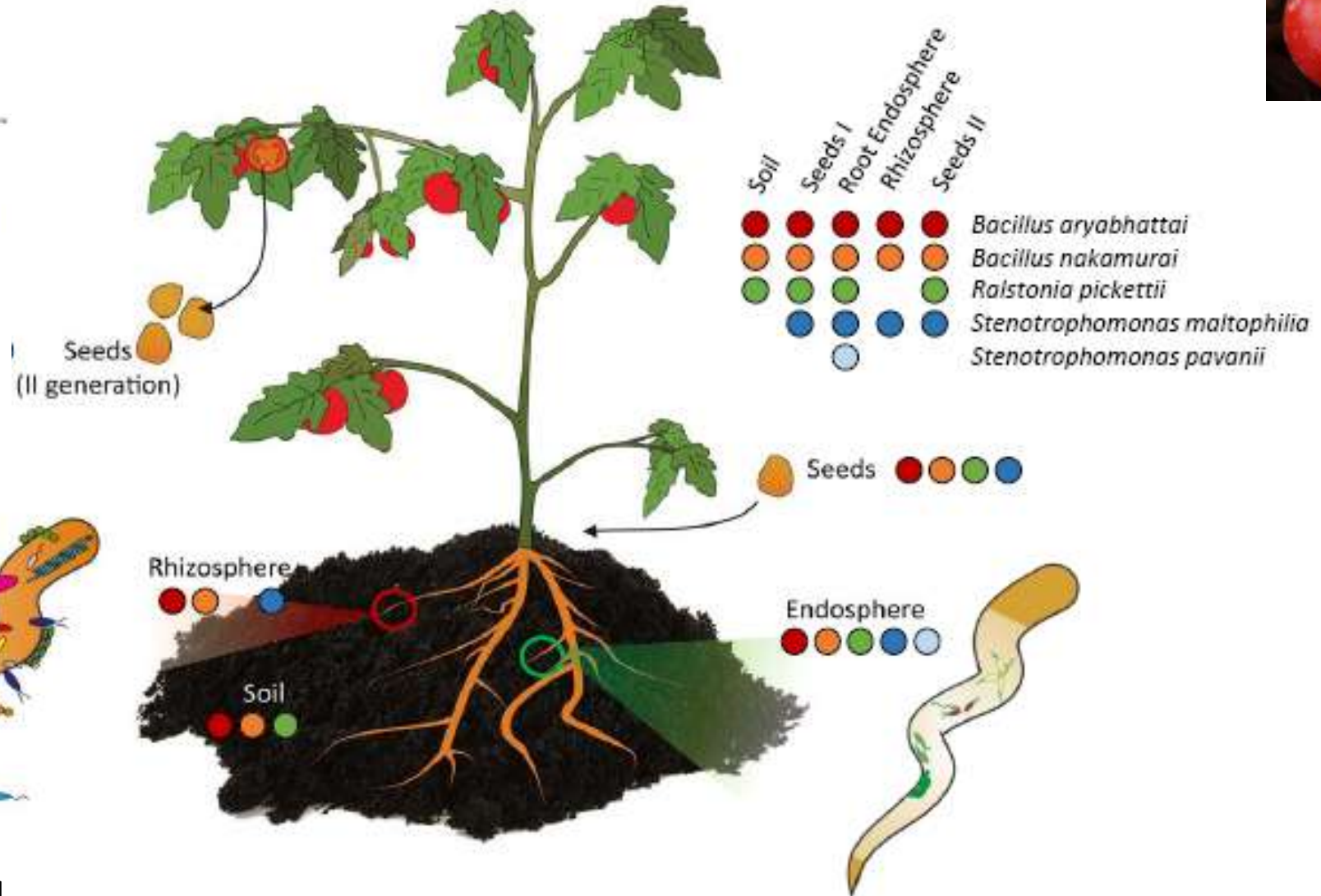
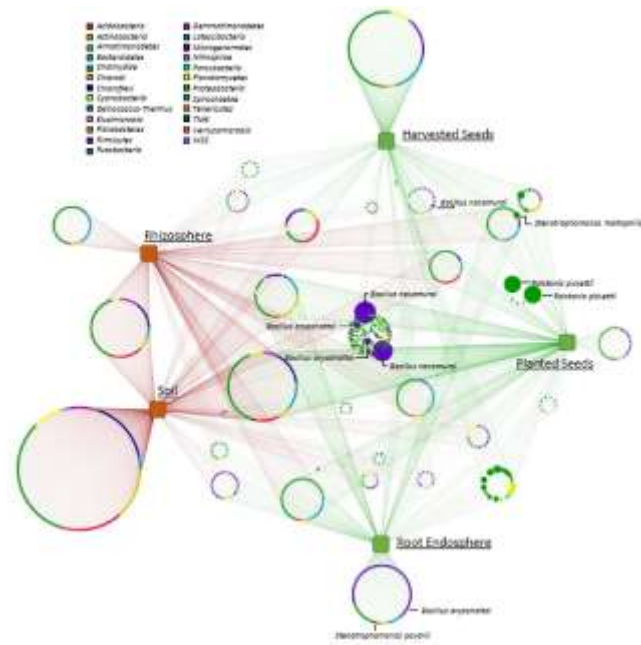




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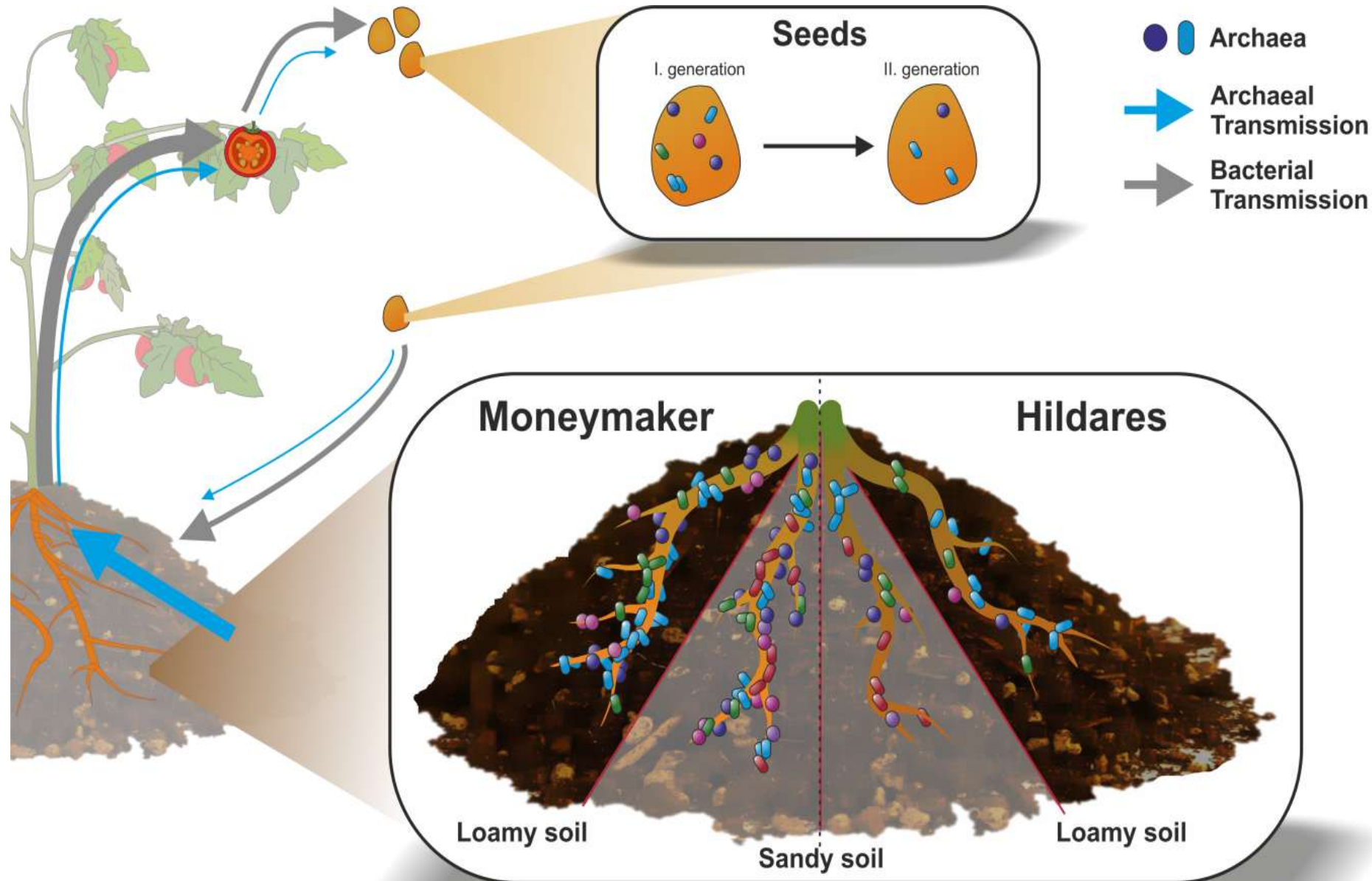


# 1. Which microbial biodiversity is associated with tomatoes?





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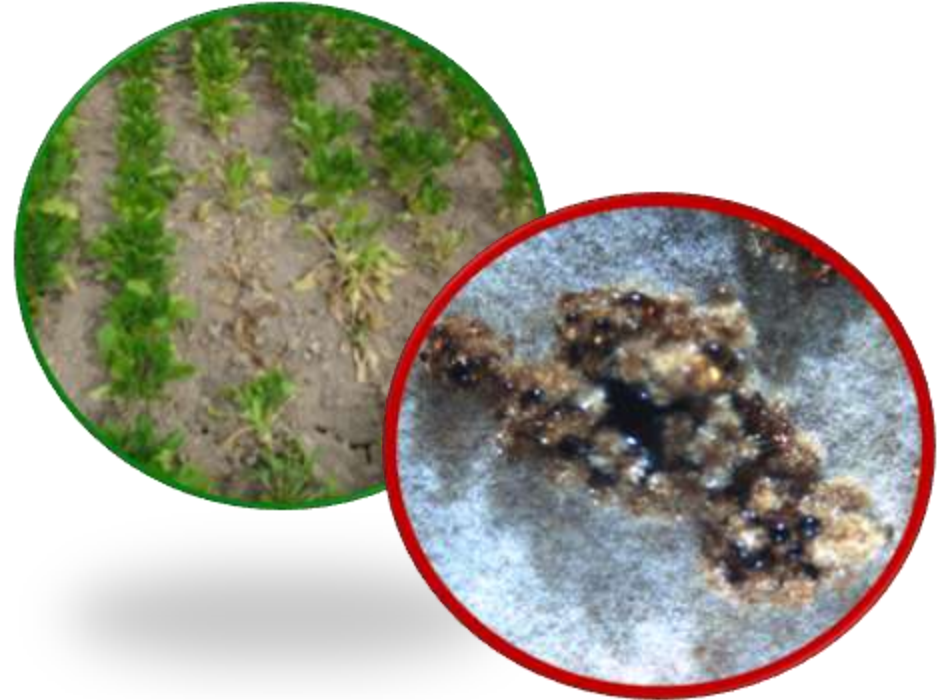


# 1. Seeds transmit a functional core microbiome



## Oilseed Rape

- *Verticillium longisporum*
- *Serratia* & *Paenibacillus*



## Sugar beet

- *Rhizoctonia solani*
- *Pseudomonas poae*

**The microbiome correlates with resistance**

[Rybakova *et al.* Microbiome 2017, Zachow *et al.*, unpublished data]



# CONCLUSION: The plant microbiome

## The Plant microbiome

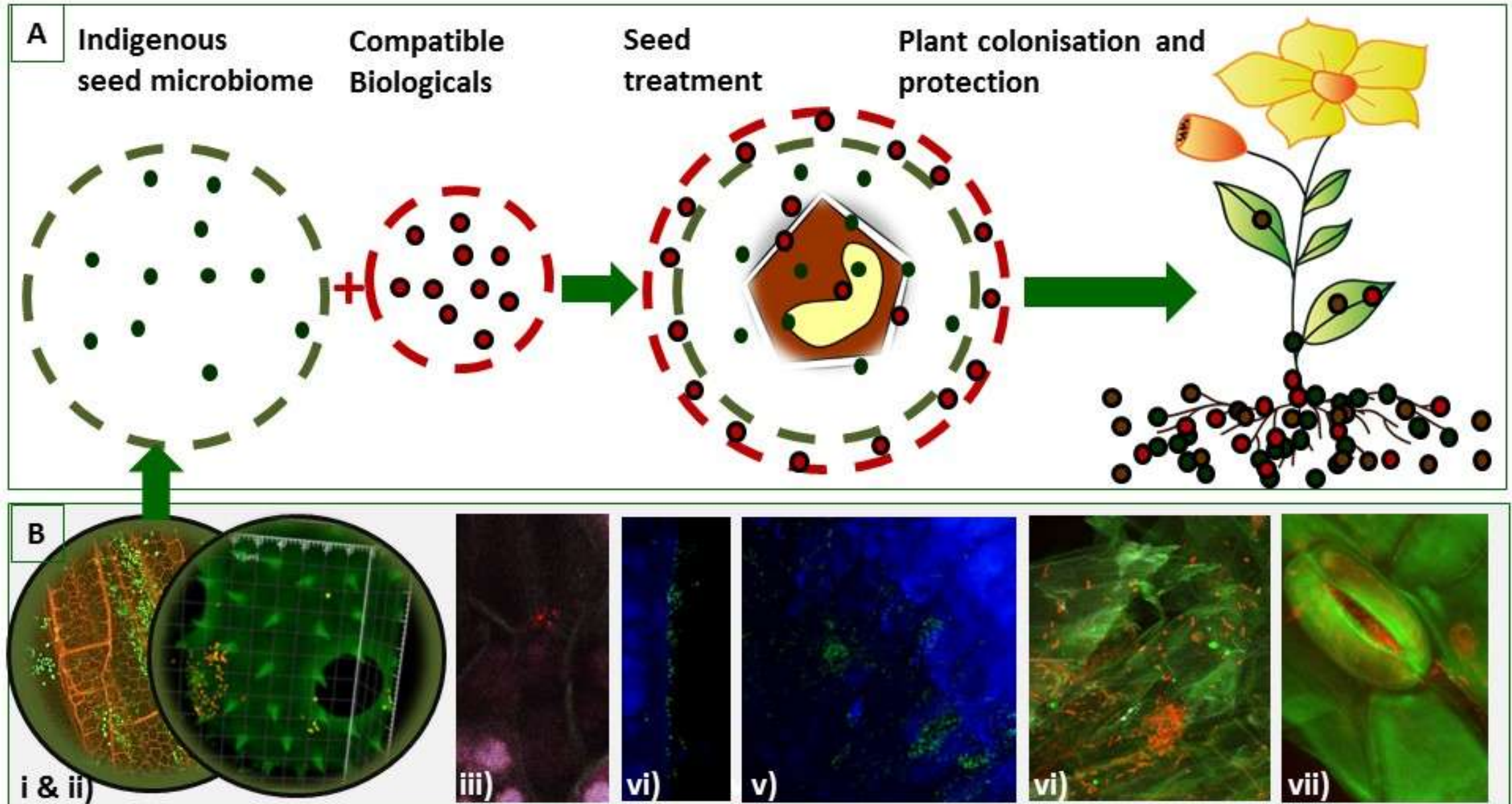
- Was shaped by co-evolution
- Has important function for the holobiont
- Is vertically transmitted by seeds
- Was shaped by breeding
- Is specific for plant species
- Changed during plants life cycle

**A healthy plant microbiome is highly diverse, rich and evenly structured.**

**The seed is an ideal carrier for microbials.**



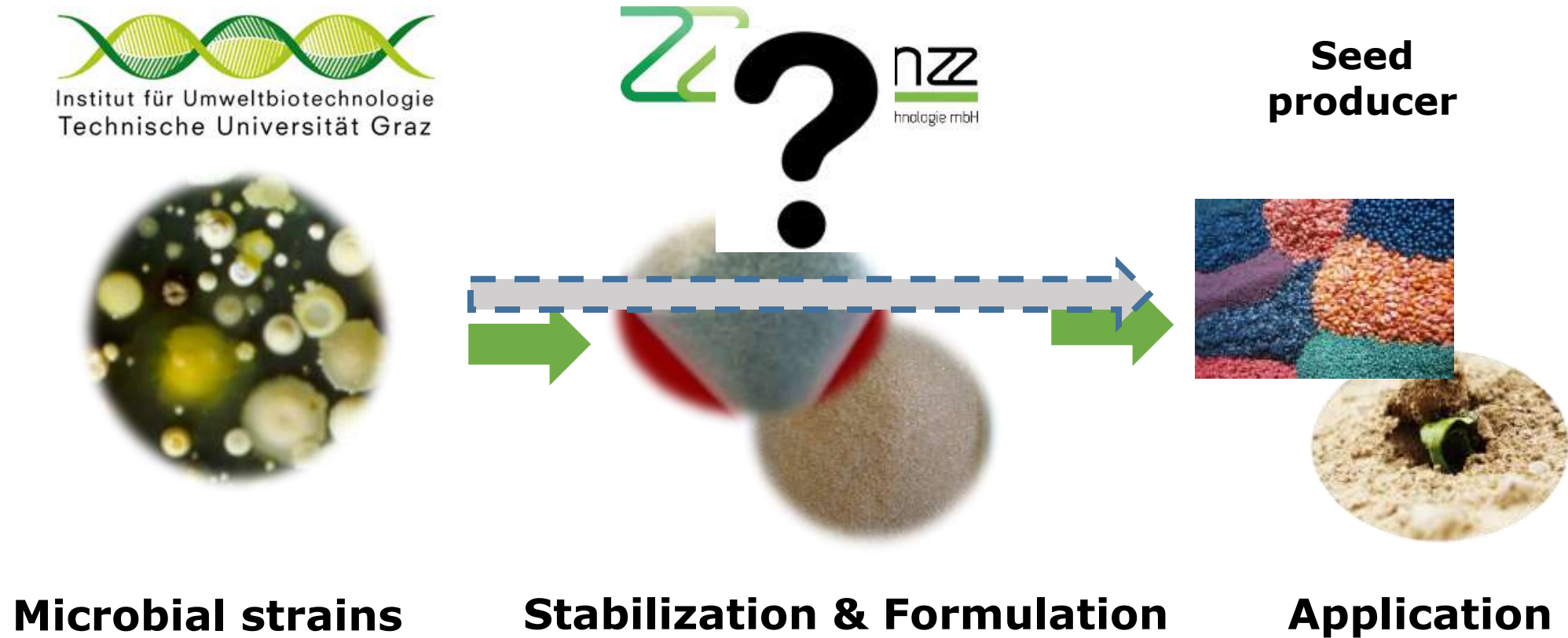
# Solution: Improving the seed microbiome





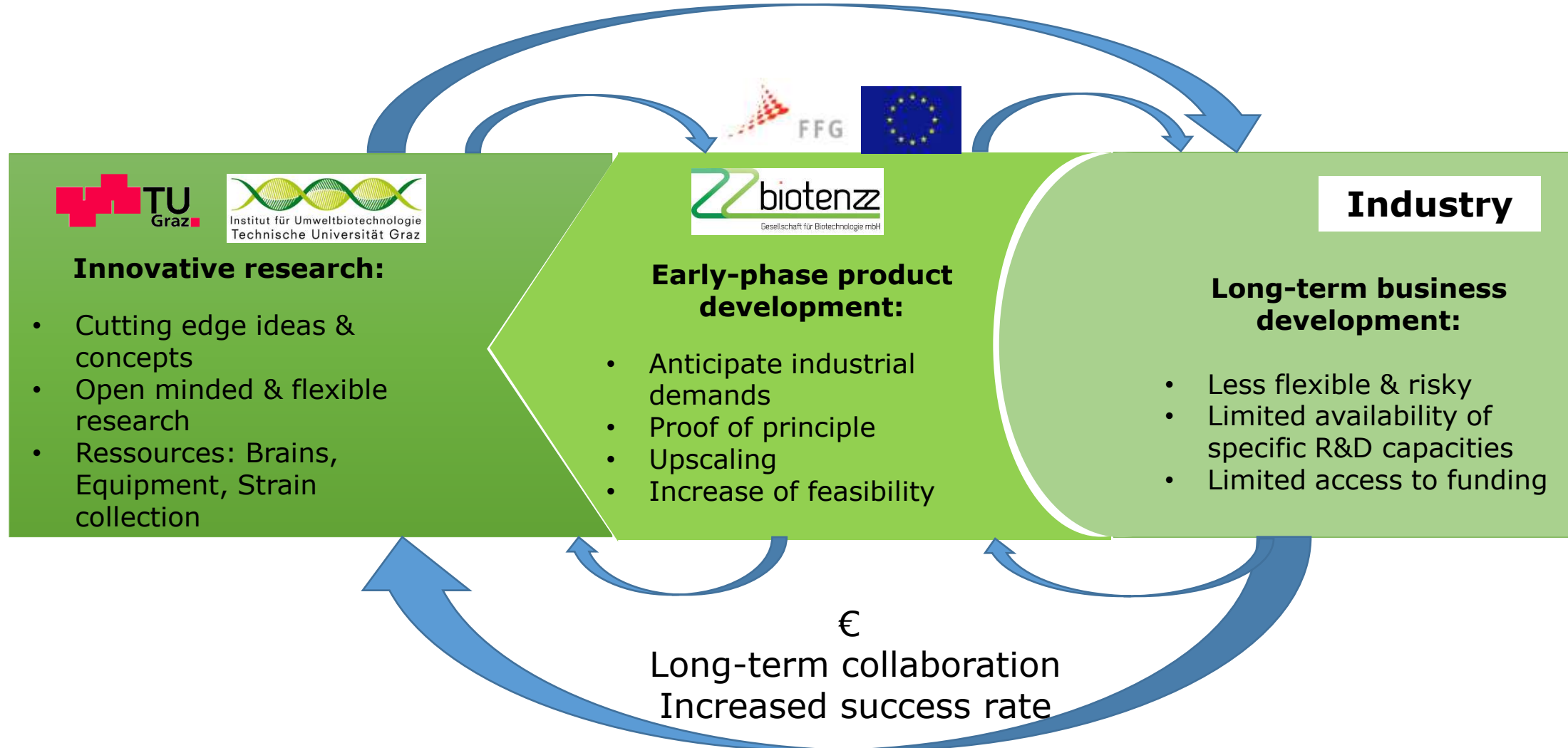
## 2. Product development & Translation

❖ Bridging the gap between research and industry



## 2. Product development & Translation

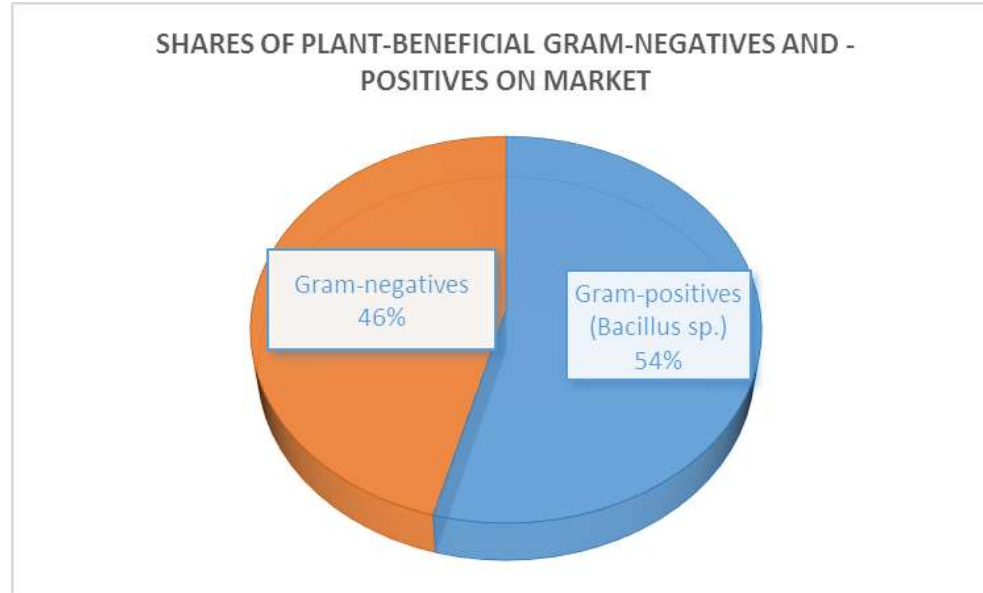
- ❖ **Spin-off company** associated with the Institute of Environmental Biotechnology
- ❖ **Our expertise:** Novel formulations for enhanced shelf-life of microbial products



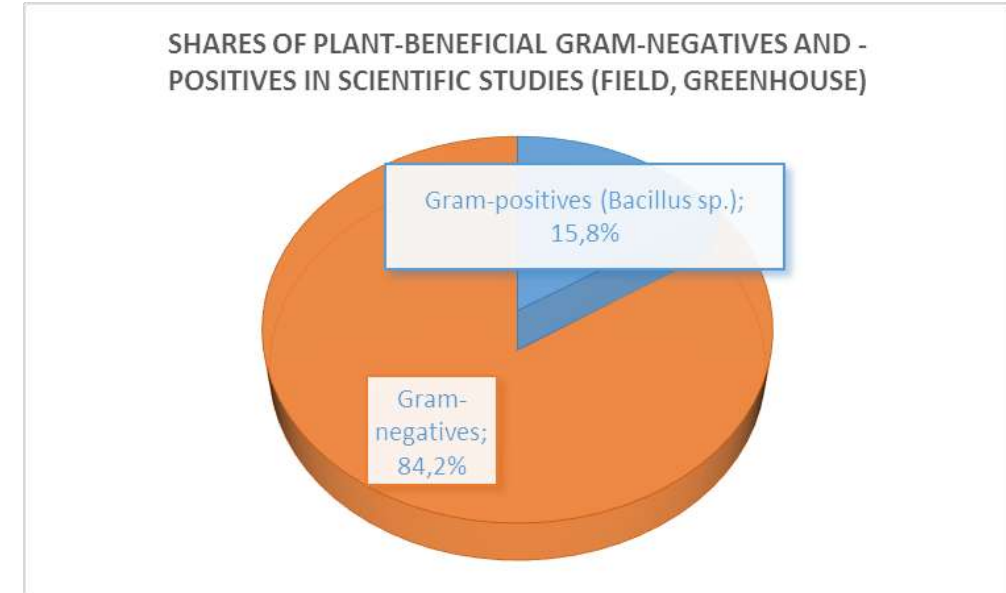


## 2. Product development & Translation

Market situation evinces the current bottleneck for commercialization of microbial products



Firmicutes-based products dominate market



Studies reveal greater potential of Gram-negatives

**Our aim: A key technology enabling exploitation of full microbial potential for agriculture**

## **2. Product development & Translation**

**Major achievement after 7 years of hard work**

### **„Bacterial & Fungal Conservation Technology“**

**BFC technology is an unique formulation process, that**

- Breaks limitation of using only spore-forming bacteria
- Flexibility allows application for a broad spectrum of microbial groups
- Produces highly stable products containing Gram-negatives
- Enhances the shelf-life of sensitive bacteria from several weeks to more than one year
- Is suitable for industrial-scaled processes

## 2. Product development & Translation

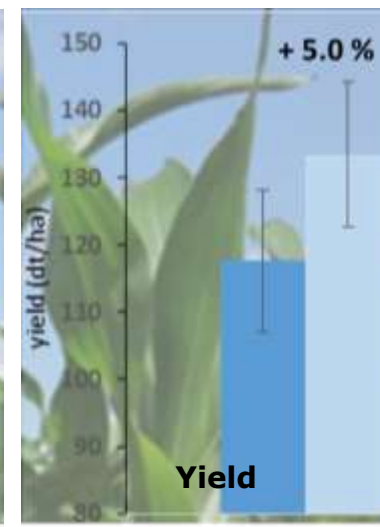
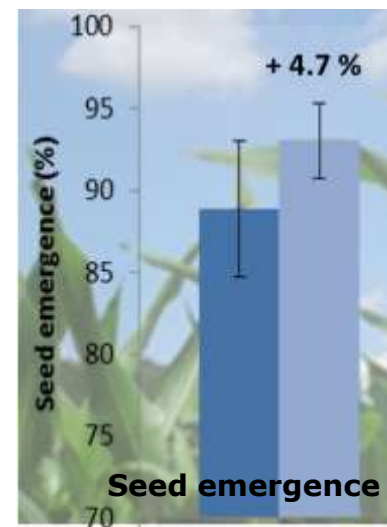
### Abiotic-stress-protecting agent: *Stenotrophomonas rhizophila* SPA P69

#### Field & Greenhouse trials in Uzbekistan

- Elevate stress tolerance of plants exposed to salinity and high temperatures

#### Field & Greenhouse trials in Austria

- Improves germination rate and drought tolerance in maize, oilseed rape, tomato, sweet pepper



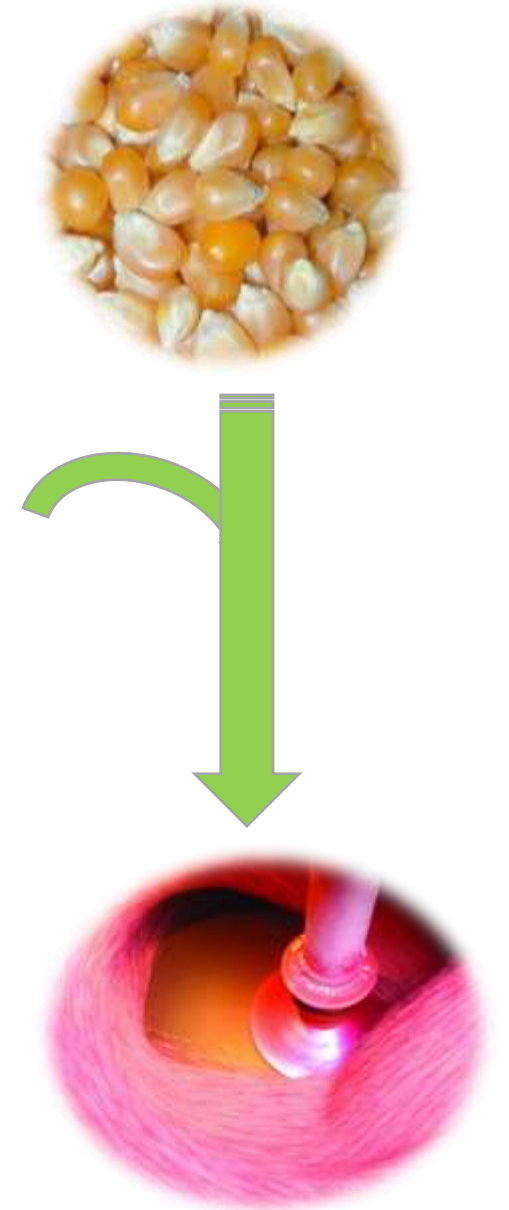
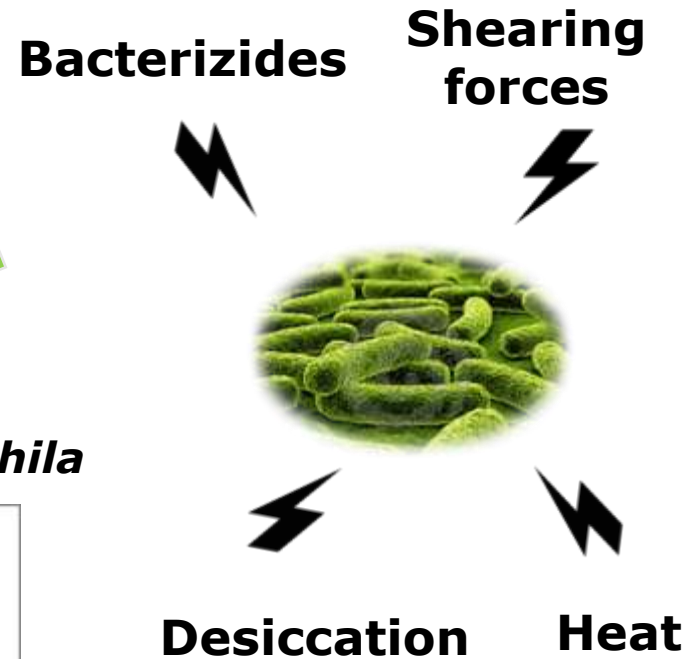
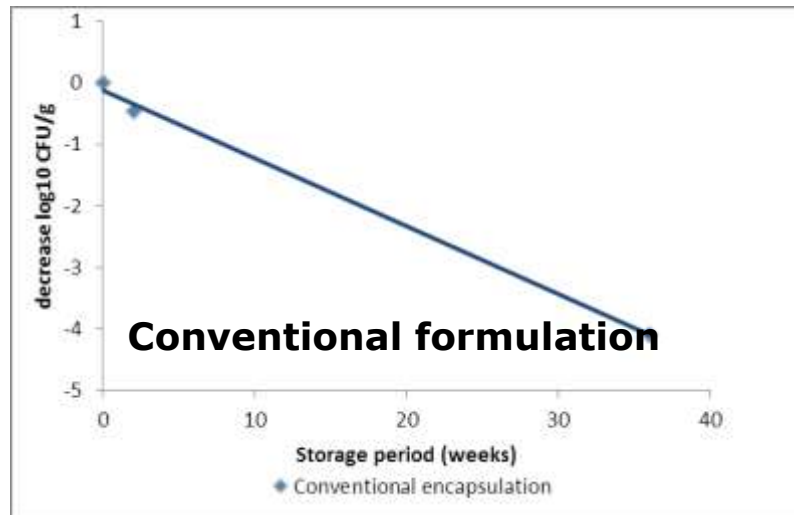


## 2. Product development & Translation



Stress protecting agent  
*Stenotrophomonas rhizophila*  
SPA P69

Survival rates of formulated *S. rhizophila*



## 2. Product development & Translation



Stress protecting agent  
*Stenotrophomonas rhizophila*  
SPA P69

Bacterial & Fungal  
conservation  
technology



Bacterizides

Shearing  
forces

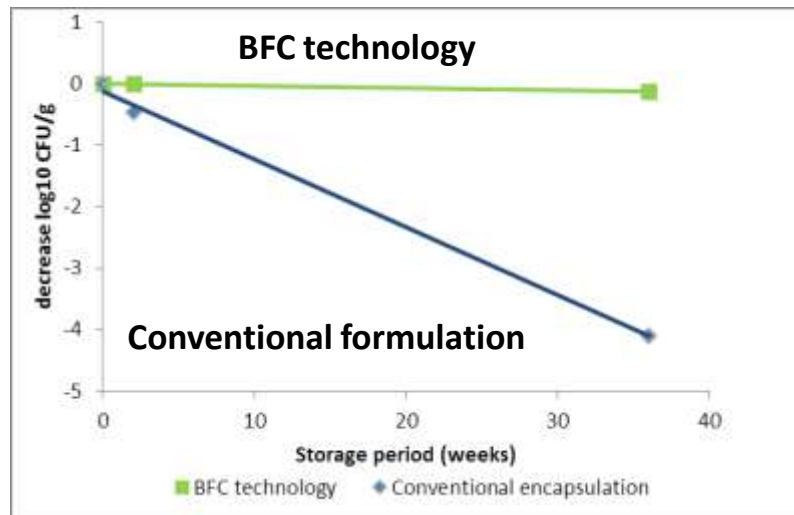


Desiccation

Heat



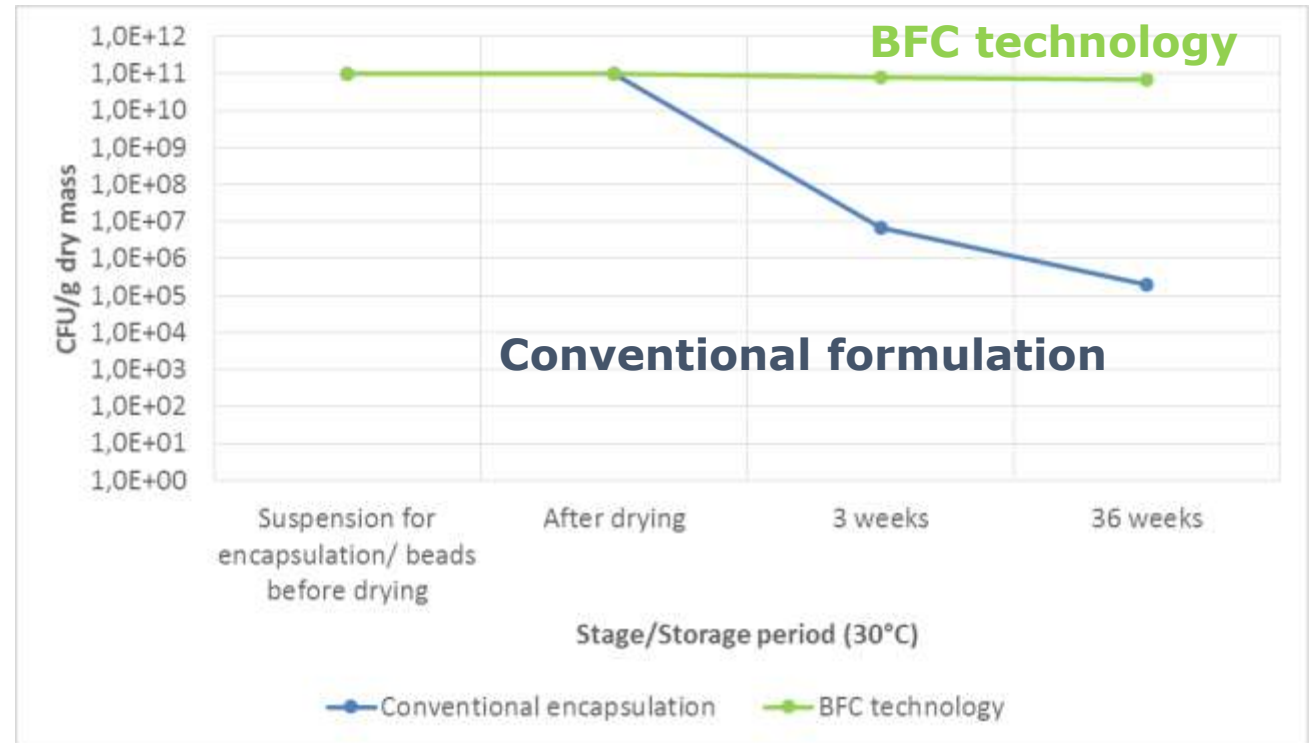
Survival rates of formulated *S. rhizophila*



## 2. Product development & Translation

**Plant beneficial microorganisms  
(bio-control, plant growth  
promotion)**

*Serratia* sp.  
*Pseudomonas* sp.  
*Lysobacter* sp.  
*Stenotrophomonas* sp.



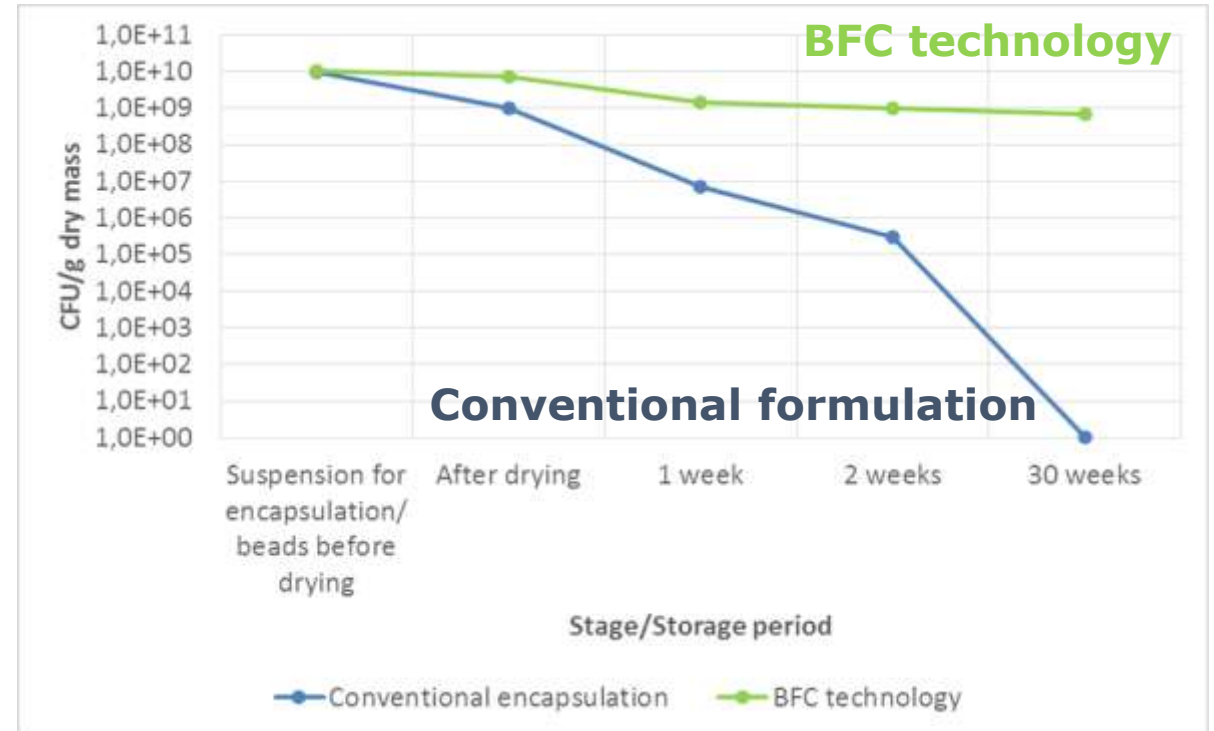
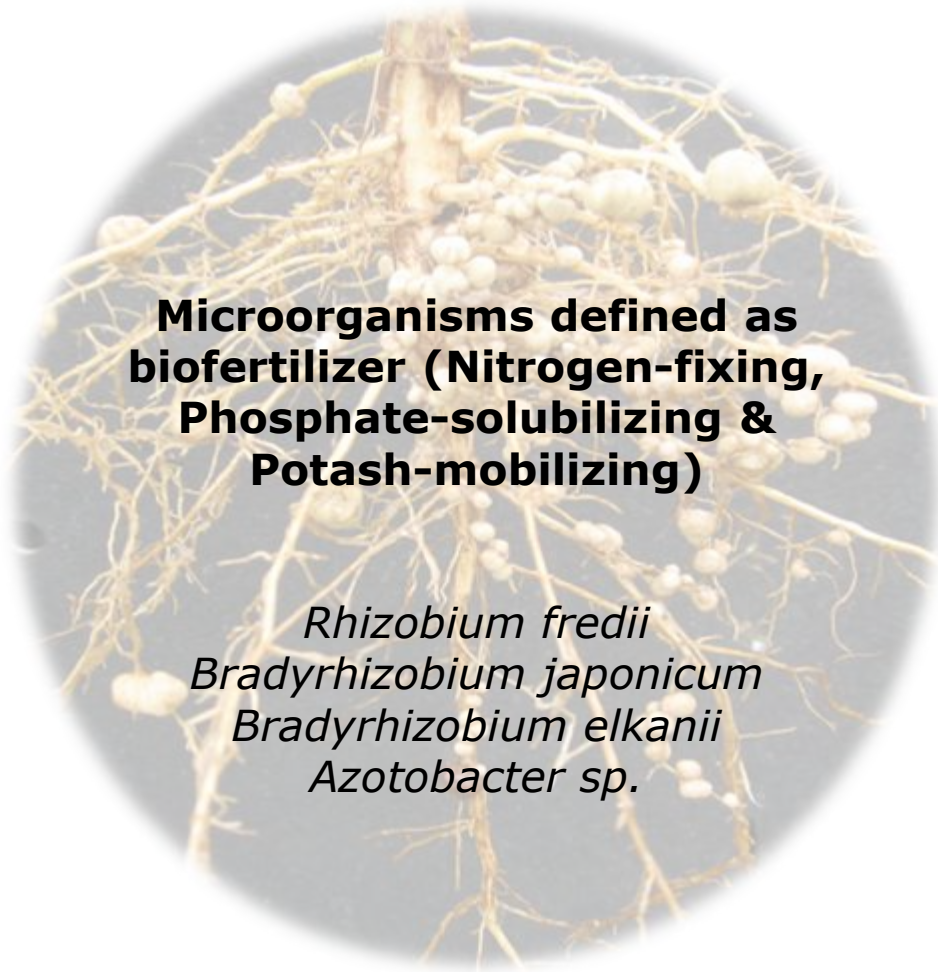
***Stenotrophomonas rhizophila* SPA P69**

(Stress protecting agent)

Storage conditions: 36 weeks at 30°C



## 2. Product development & Translation



***Rhizobium fredii* DSM-5851**

Storage conditions: 30 weeks at 30°C

## 2. Product development & Translation



### 3-bacteria mixture

- Combats late root rot (*Rhizoctonia solani*) in sugar beet



### 7-bacteria mixture

- Enhances seed germination
- Seedling's growth and health

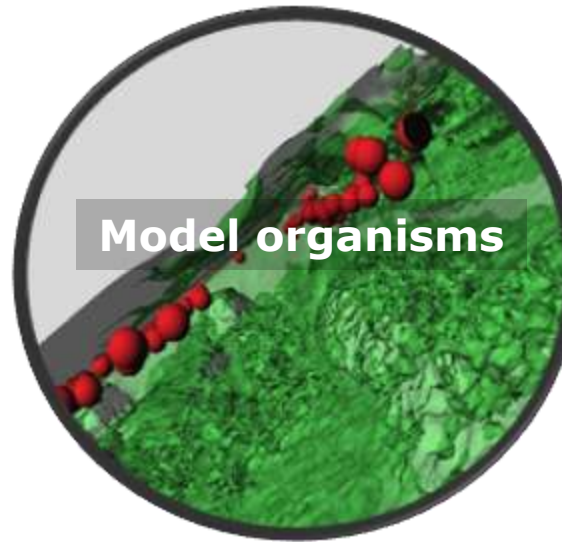


### 4-bacteria + fungus mixture

- Improves seed germination and plant health
- Increases yield



# Successful translation from idea to industrial application!



Translation

