The microbiome and its influence on plant growth and health

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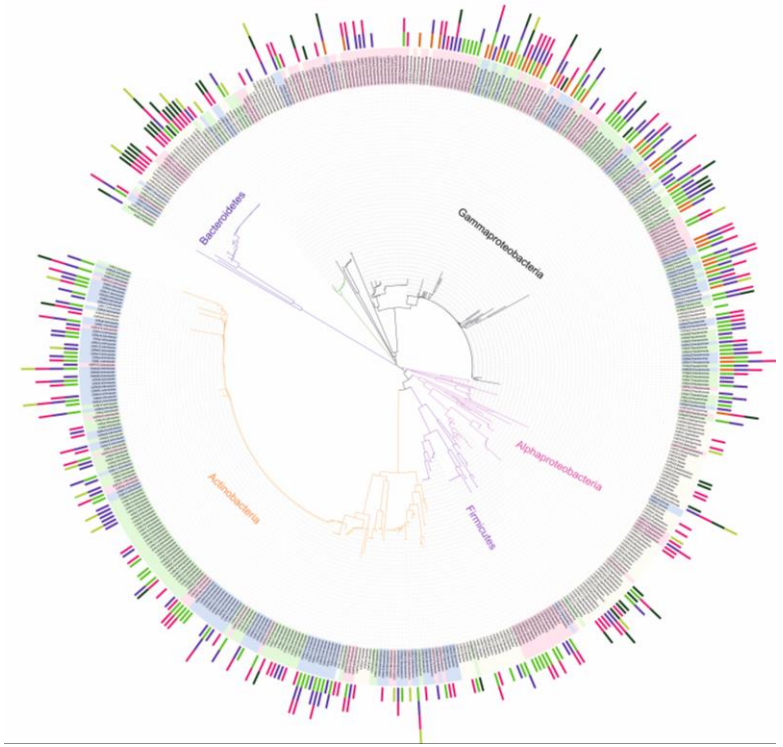
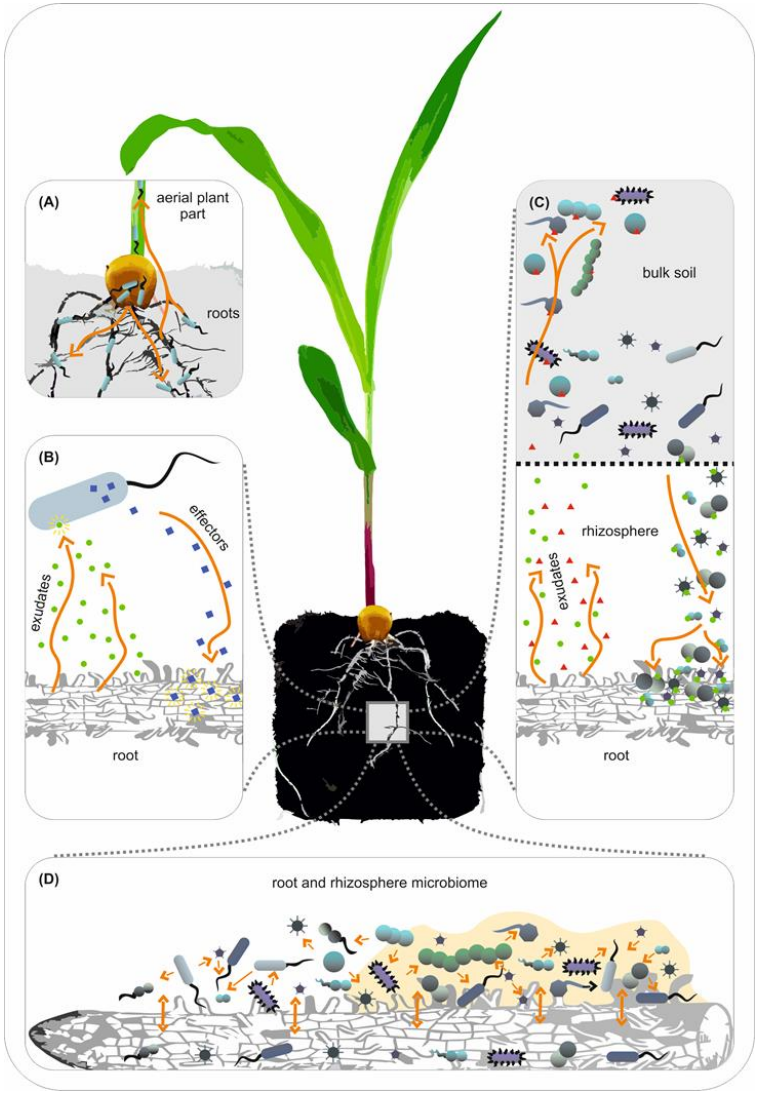


Fact sheet:

- 82% of variation in carbon cycling are explained by microbiological soil indicators
- Increase in soil fauna increases plant productivity by 35%
- Bacterial microbes contribute to enhanced plant nutrition
- In low level soil biodiversity, additional input improves ecosystem functioning (intensive agriculture land use system have low soil biodiversity)
- Soil biodiversity may have an implication for ecosystem stability under environmental changes (global warming)
- Increase soil biodiversity can reduce the ability of a pathogen to colonize in soil

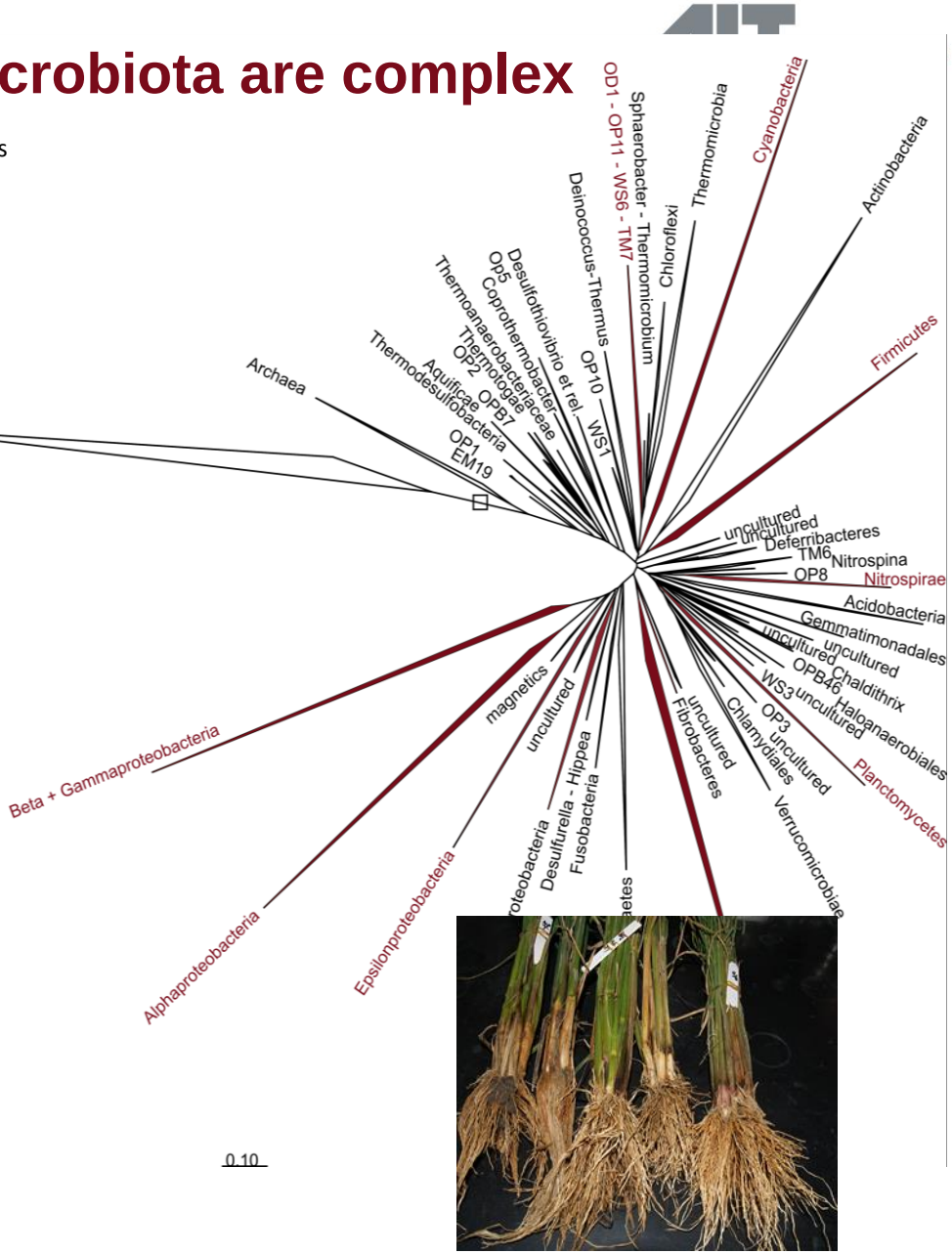
Bender et al 2016. An underground revolution: biodiversity and soil ecological engineering for agriculture sustainability. Trends Ecol&Evol.



Mitter et al, 2016, Microb. Biotechnol.

Plant and soil microbiota are complex

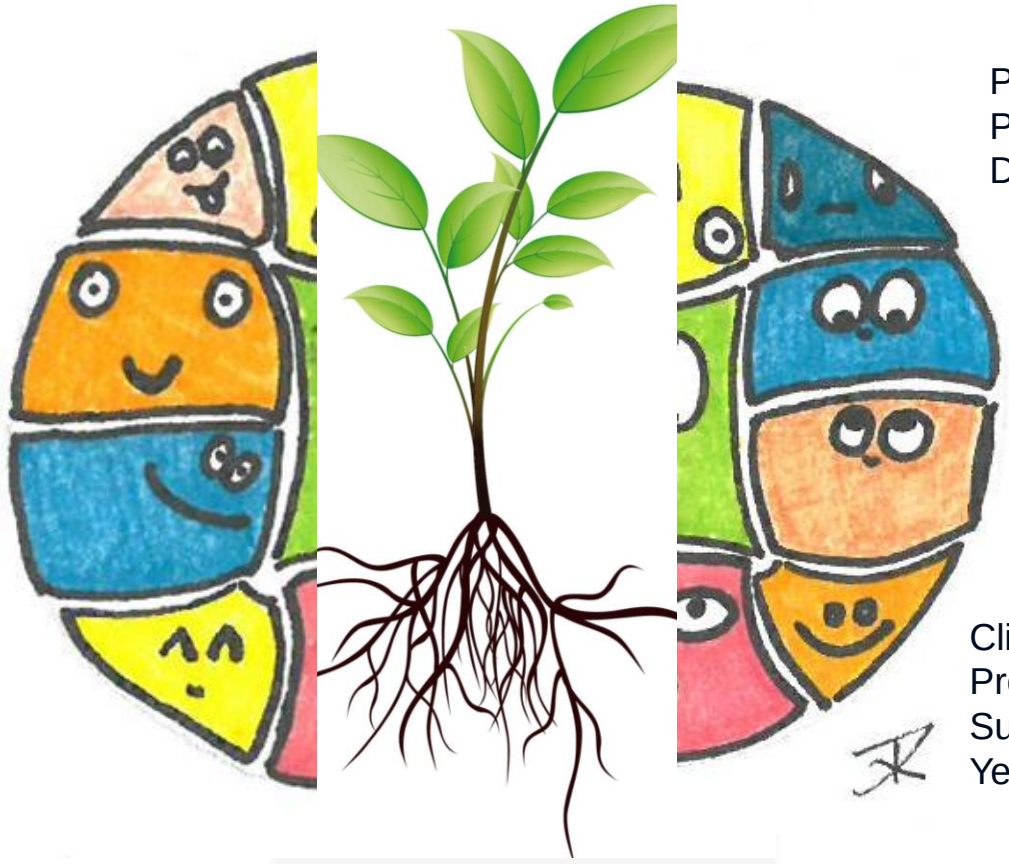
Phylogenetic affiliation		No. of sequences	% sequences
Bacteria		7.319	
	Acidobacteria	53	0.72
	Actinobacteria	1.461	19.88
	Armatimonadetes	6	0.08
	Bacteroidetes	462	6.29
	GOUTA4c	1	0.01
	ODc	6	0.08
	TM7c	2	0.03
	Chlamydiae	8	0.11
	Chlorobi	5	0.07
	Chloroflexi	3	0.04
	Cyanobacteria	102	1.39
	Deinococcus-Thermus	7	0.1
	Elusimicrobia	1	0.01
	Firmicutes		
	Bacilli	1.132	15.41
	Clostridia	68	0.93
	Fusobacteria	3	0.04
	Nitrospirae	3	0.04
	Planctomycetes	5	0.07
	Proteobacteria		
	Alpha-	1.337	18.2
	Beta-	736	10.02
	Delta-	26	0.35
	Epsilon-	3	0.04
	Gamma-	1.878	25.56
	Spirochaetae	3	0.04
	Tenericutes	2	0.03
	Verrucomicrobia	6	0.08
Archaea		29	
	Euryarchaeota	23	0.31
	Thaumarcheota	6	0.08
Total		7.348	



Hardoim et al., 2015, Microbiol. Mol. Biol. Rev.

The holobiont plant – drivers of the plant microbiome

Agricultural practice
- Pesticides
- Fertilizer
- Biologicals
- Cultivation



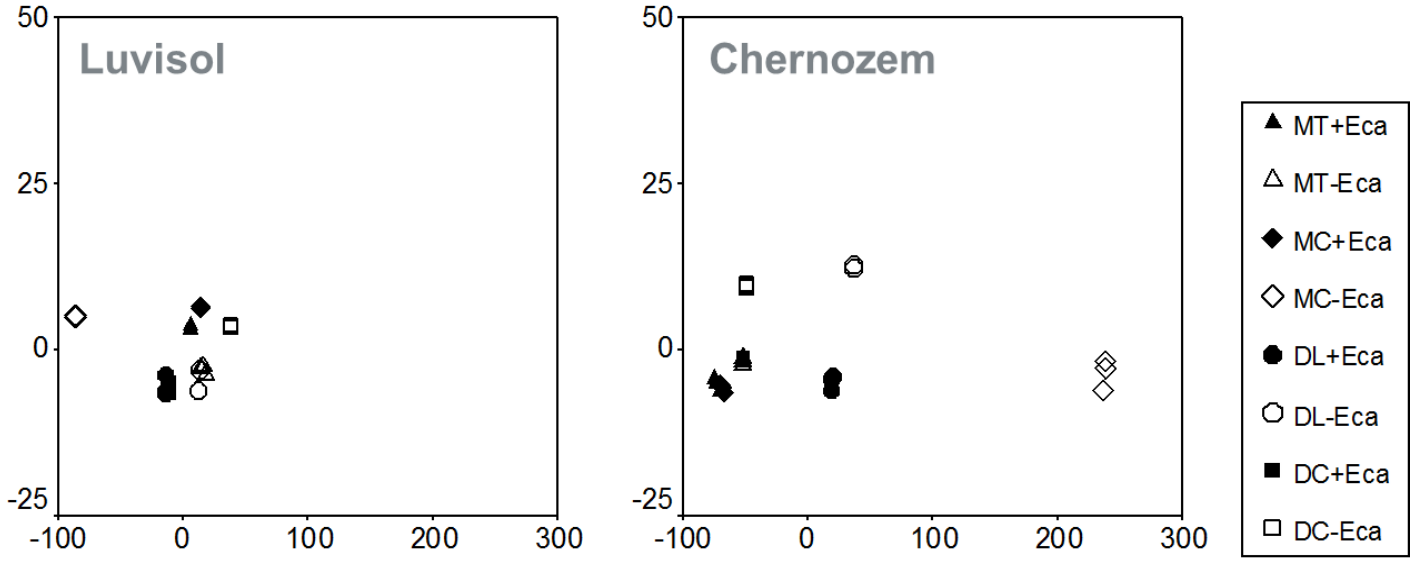
Plant Genotype
Plant Species
Development stage

Biotic and abiotic

Climate
Precipitation
Sun irradiation
Year

Drivers of the plant microbiome under controlled conditions

Soil > vegetation stage > pathogen exposure > plant genotype

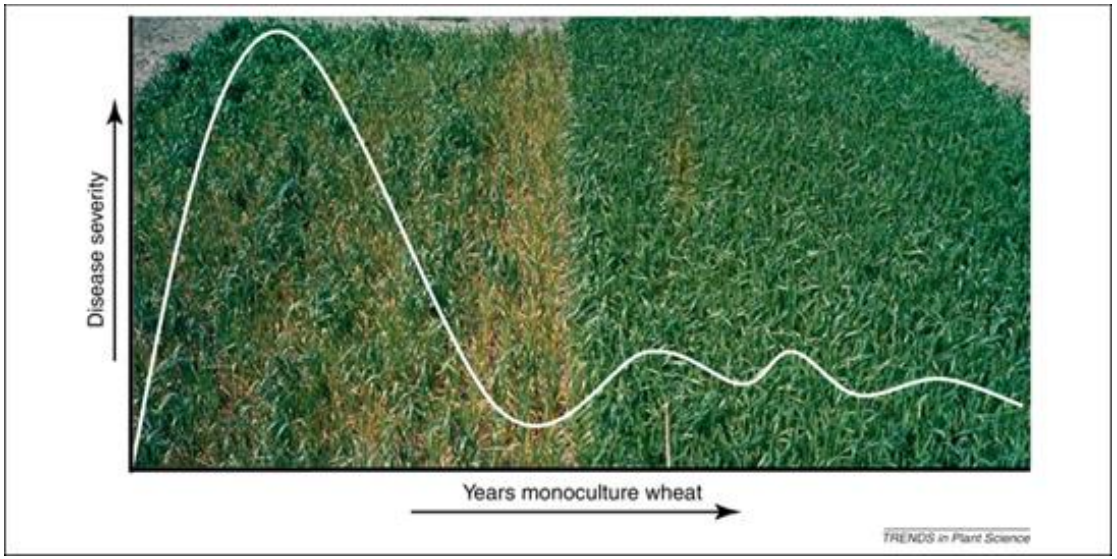


Rasche et al., 2006. Appl. Ecol.

Potato cultivars
MT: GM Merkur
MC: Merkur
DL: GM Desiree
DC: Desiree

Treated with and without *Pectobacterium carotovorum*

Importance of the soil microbiome: Disease suppressive soil



Berendsen et al. 2012
The rhizosphere microbiome and plant health

After several year of monoculture a suppression of disease incidence is observed

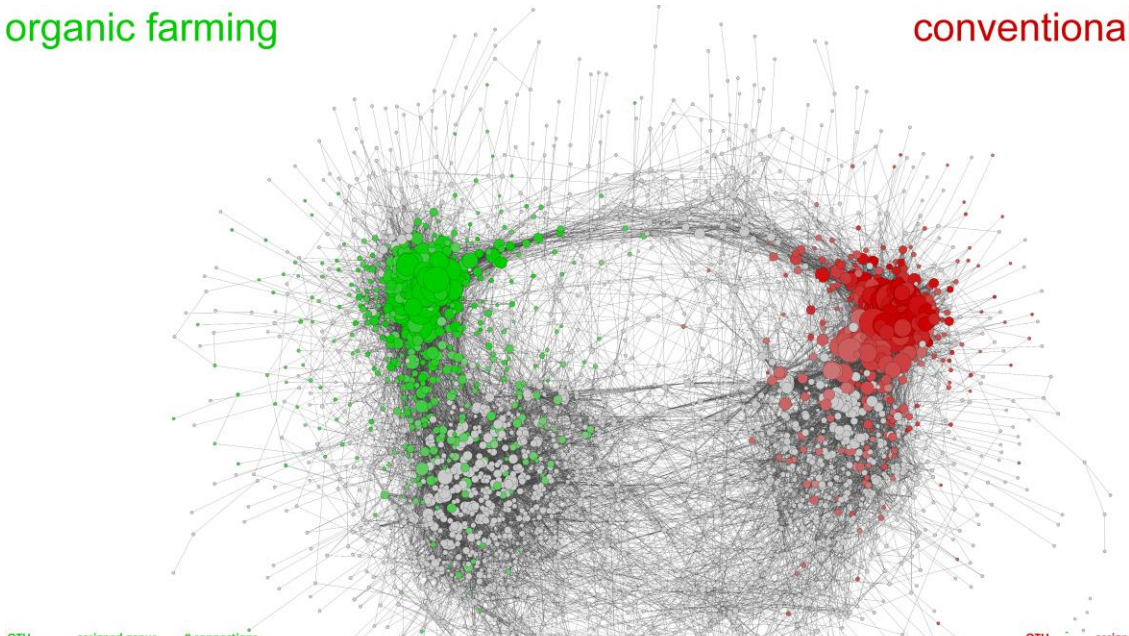
→ Role of the soil microbiome found

Pseudomonas haplotypes constituted 90% of the antagonistic effect

Different Pseudomonas haplotypes contribute to different types of disease suppression

Mendes, R. et al. 2011. Deciphering the rhizosphere microbiome for disease-suppressive bacteria. Science *332*, 1097-1100.

Fact: the soil microbiome is different in organic and conventional farming



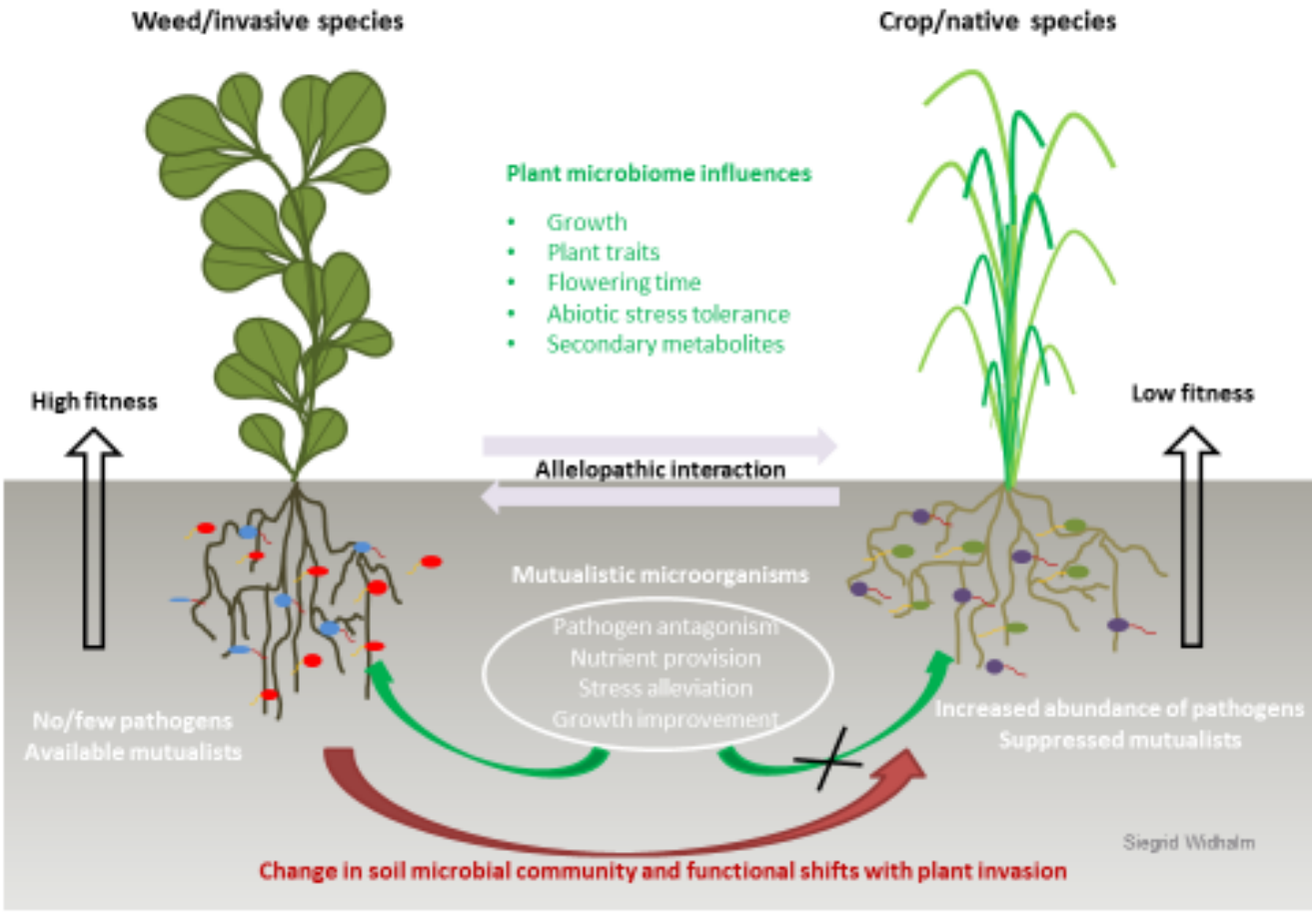
OTU	assigned genus	# connections
BOTU2056	Balneimonas	142
BOTU0147	C. Entotheonella	125
BOTU2582	Ureibacillus	114
FOTU2470	Podospora	99
FOTU2063	Acaulospora	69
BOTU2987	Catellatospora	68
BOTU2385	Pseudonocardia	63
BOTU2888	Iamia	56
BOTU2730	Cytophaga	54
FOTU2251	Entrophospora	52
BOTU1947	Desulfuromonas	51
BOTU0214	Caldilinea	49
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
BOTU0411	Amaricoccus	46
FOTU1703	Paraphoma	45
BOTU2982	Terracoccus	44
BOTU3250	Thermomonospora	41
BOTU0506	Caldilinea	39

OTU	assigned genus	# connections
BOTU0150	C. Koribacter	153
BOTU1099	C. Solibacter	141
BOTU2919	C. Solibacter	126
FOTU1620	Trimmatostroma	124
FOTU1618	Trechispora	119
BOTU2841	C. Solibacter	116
BOTU0767	C. Solibacter	113
BOTU3726	Catenulispora	112
BOTU3033	Burkholderia	102
BOTU1576	Rhodanobacter	99
BOTU1578	Collimonas	90
BOTU2814	Dermacoccus	89
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
BOTU0042	Cytophaga	78
BOTU1791	Gemmatimonas	78
FOTU0304	Cryptococcus	71
BOTU0910	C. Solibacter	68
BOTU1042	C. Solibacter	67

What does the differences mean and how we can make use of it

van der Heijden MGA, Hartmann M. 2016. Networking in the Plant Microbiome. *PLoS Biol 14:e1002378*

Role of Plant associated Microorganisms



Trognitz et al. 2016 The role of plant-microbiome interactions in weed establishment and control. FEMS Microbiol Ecol. doi: 10.1093/femsec/fiw138

Microbiomes of weeds and herbicidal activities

Abdul Samad, Friederike Trognitz, Stéphane Compant & Angela Sessitsch

http://flora.nhm-wien.ac.at/index.htm

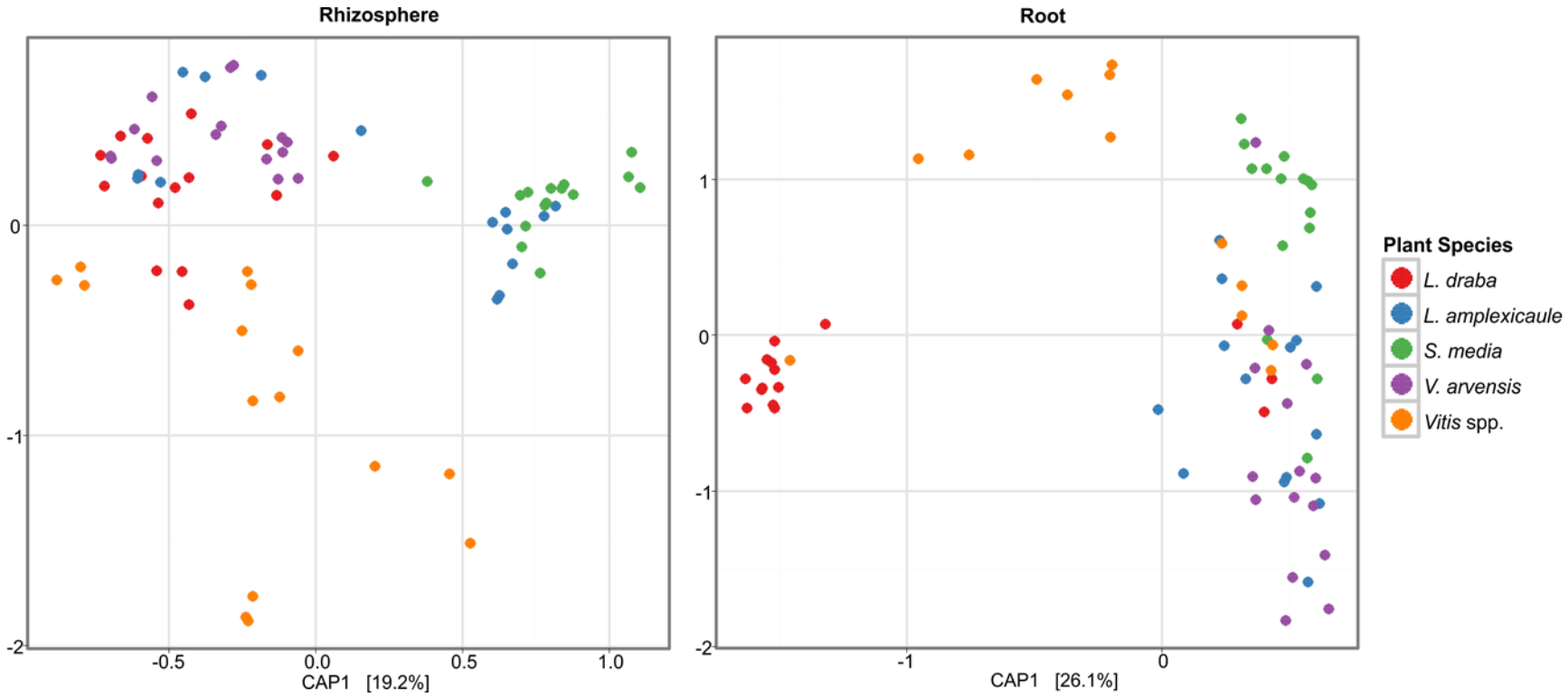
Sampling / analysis

- Sampling time: April
- Rhizosphere and root endosphere
- 16S rRNA-based microbiome analysis
- Isolation of bacteria from grapevine and *L. draba*
- Characterization of isolates

Vitis spp.
Lepidium draba L.
Lamium amplexicaule L.
Veronica arvensis L.
Stellaria media L.

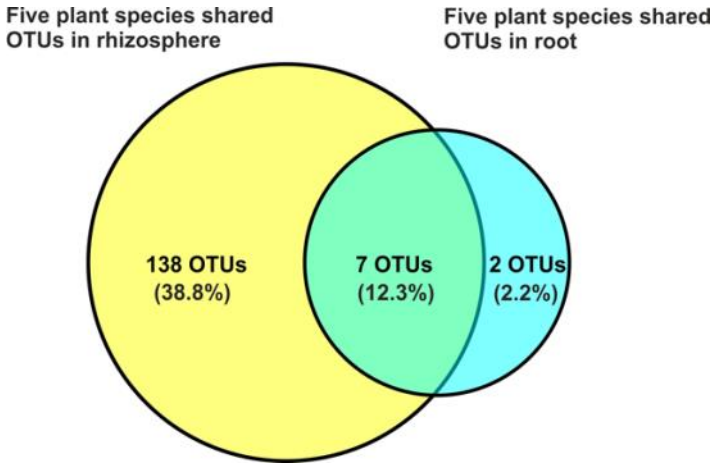
Samad et al., Shared and host-specific microbiome diversity and functioning of grapevine and accompanying weed plants; Environmental Microbiology

Grapevine and weed microbiomes

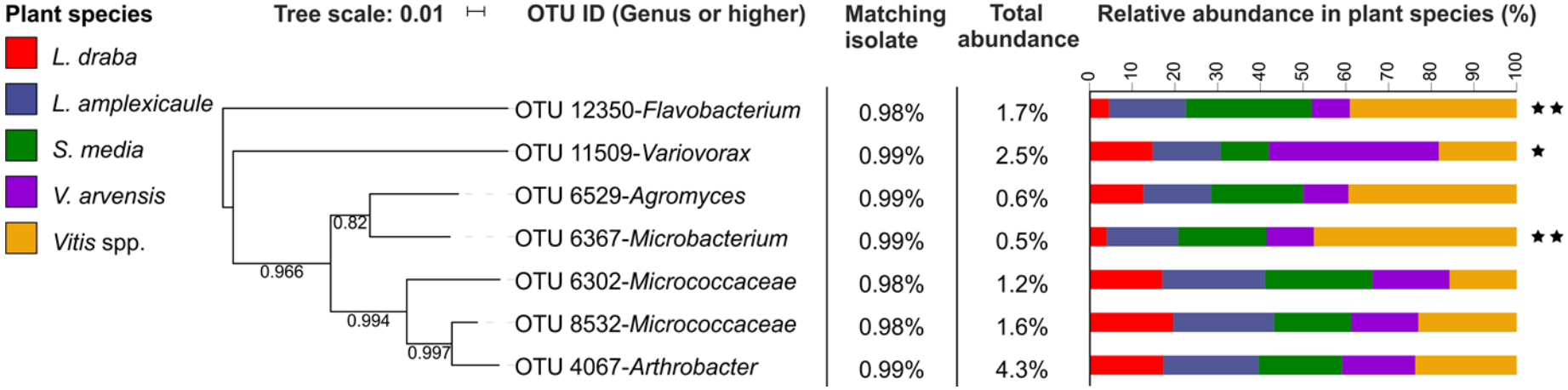


rhizosphere **roots**

Grapevine and weed microbiomes – Shared phylotypes

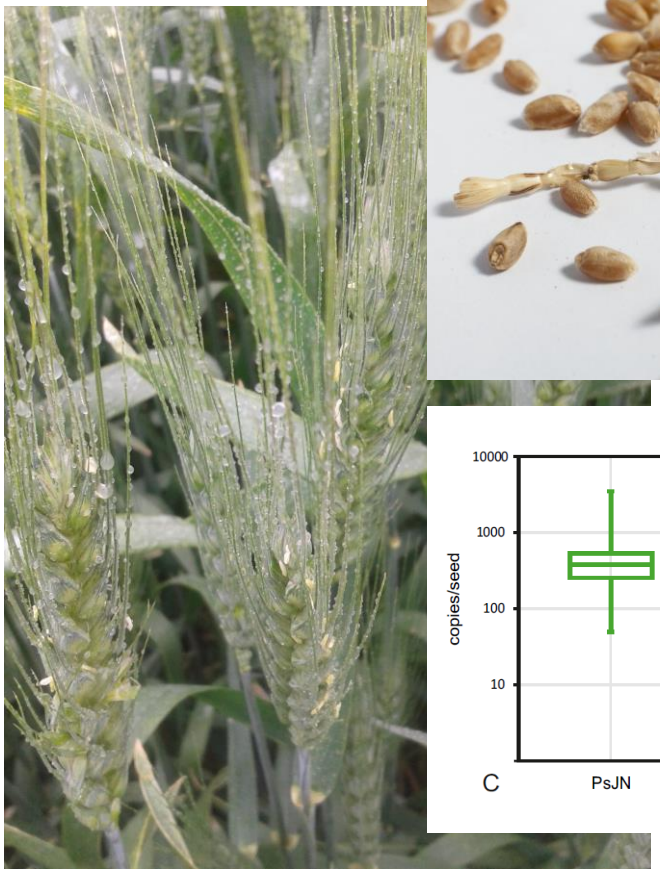


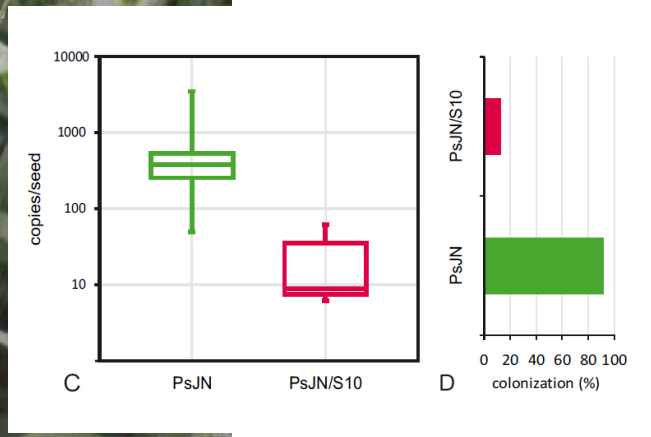
7 OTUs present in both plant compartments and in five plant species



EndoSeed in the field

- Spring wheat (*Triticum aestivum* cv. Trappe)

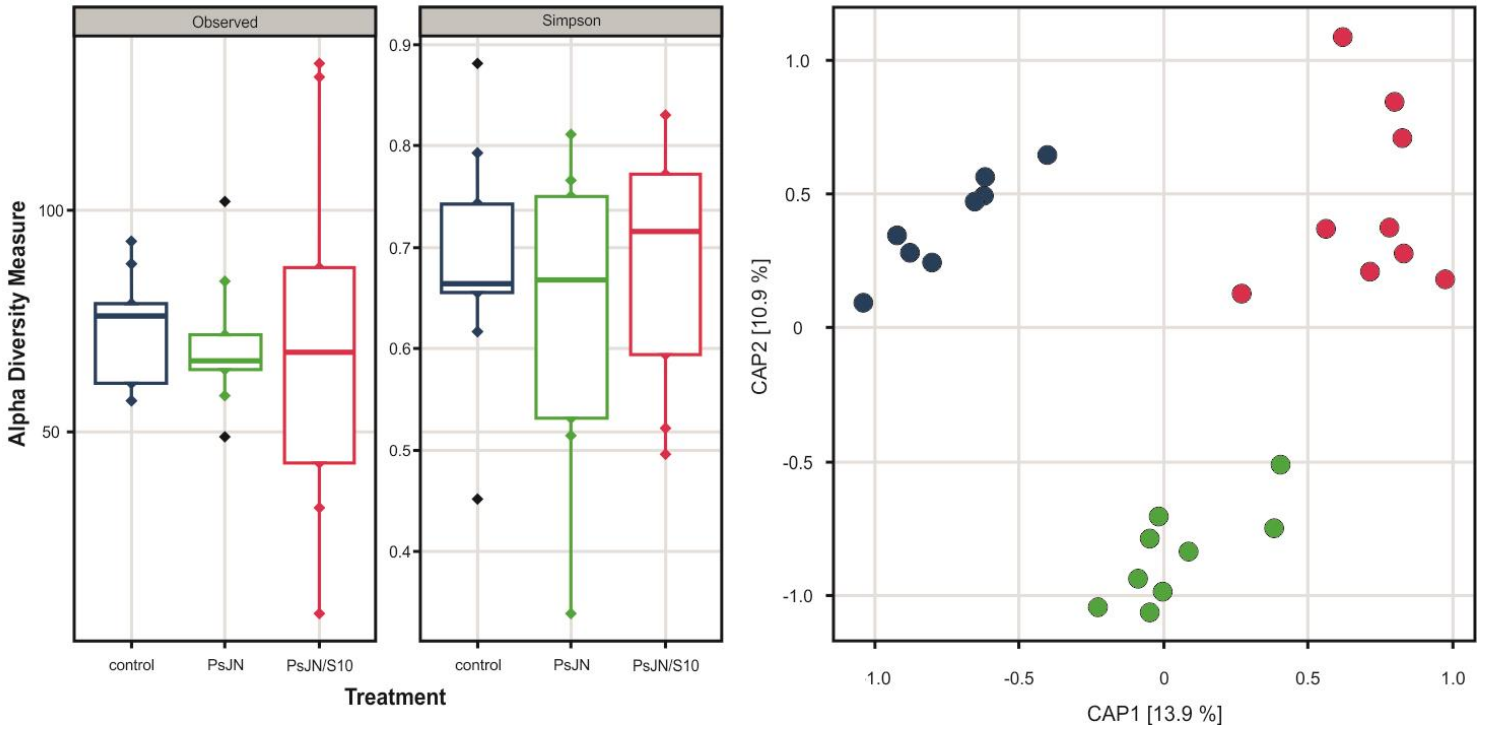




Changes in the seed microbiome due to EndoSeed™ application

Spring wheat (*Triticum aestivum* cv. Trappe)

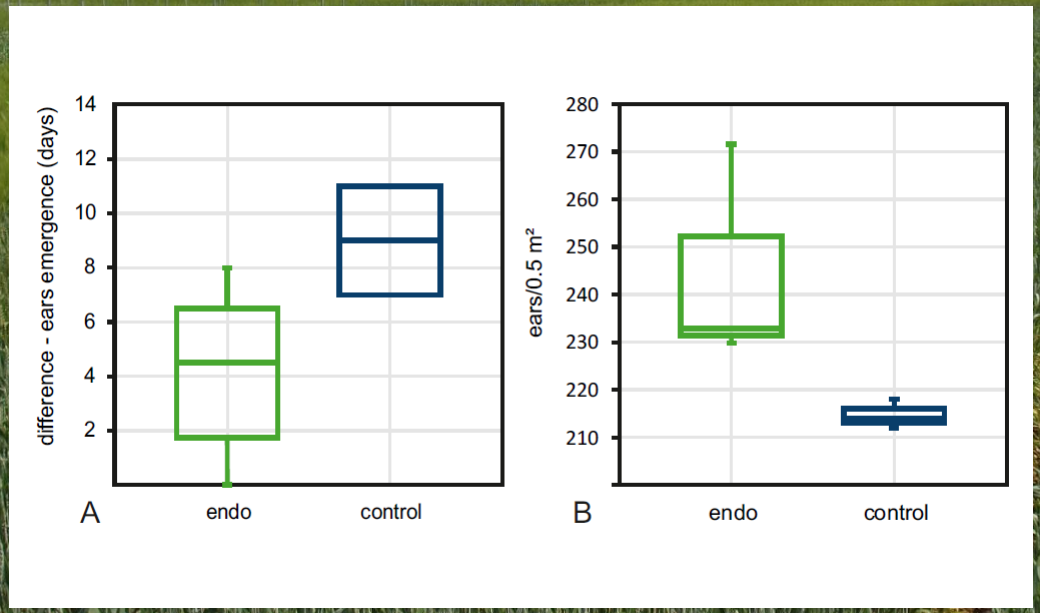
Endoseeds: Introduction of the bacteria into the seeds by spraying the flowers



B. Mitter, N. Pfaffenbichler, S. Compant, Y. Millet, N. Muhammad, L. Anotnielli, TG. Maltzahn, A. Sessitsch

Changes in flowering time and number of ears/head

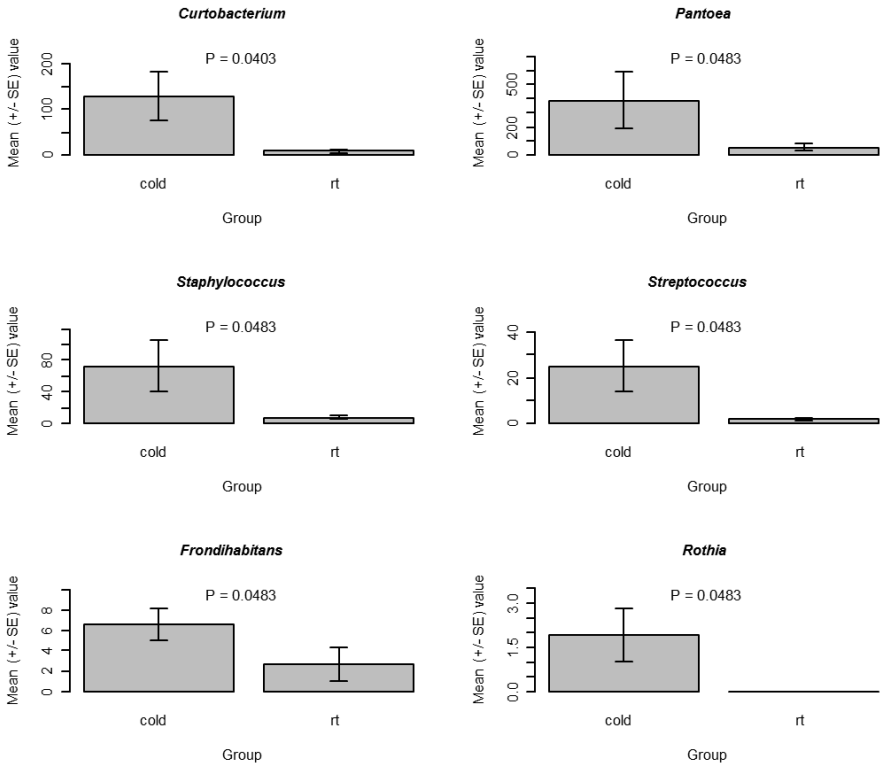
Spring wheat (*Triticum aestivum* cv. Trappe)



Seed microbiome for germination improvement

GENOTYPE	STORAGE	SAMPLE ID	Year harvested	ORIGIN	NS (%)
Long- living land race	Room temperature	LL LR A	2003	ARM	64.0
Long- living land race	-18° C	LL LR C	2003	ARM	76.5
Short- living land race	Room temperature	SL LR A	2003	ARM	3.0
Short- living land race	-18° C	SL LR C	2003	ARM	85.0
Long- living cultivar	Room temperature	LL BL A	1998	ARG	20.0
Long- living cultivar	-18° C	LL BL C	1998	ARG	80.0
Short- living cultivar	Room temperature	SL BL A	1998	MEX	3.5
Short- living cultivar	-18° C	SL BL C	1998	MEX	81.5

Microbiome Analysis: To find the responsible strain in a known environment



Analyzing the seed microbiome of summer wheat stored under cold and room temperature

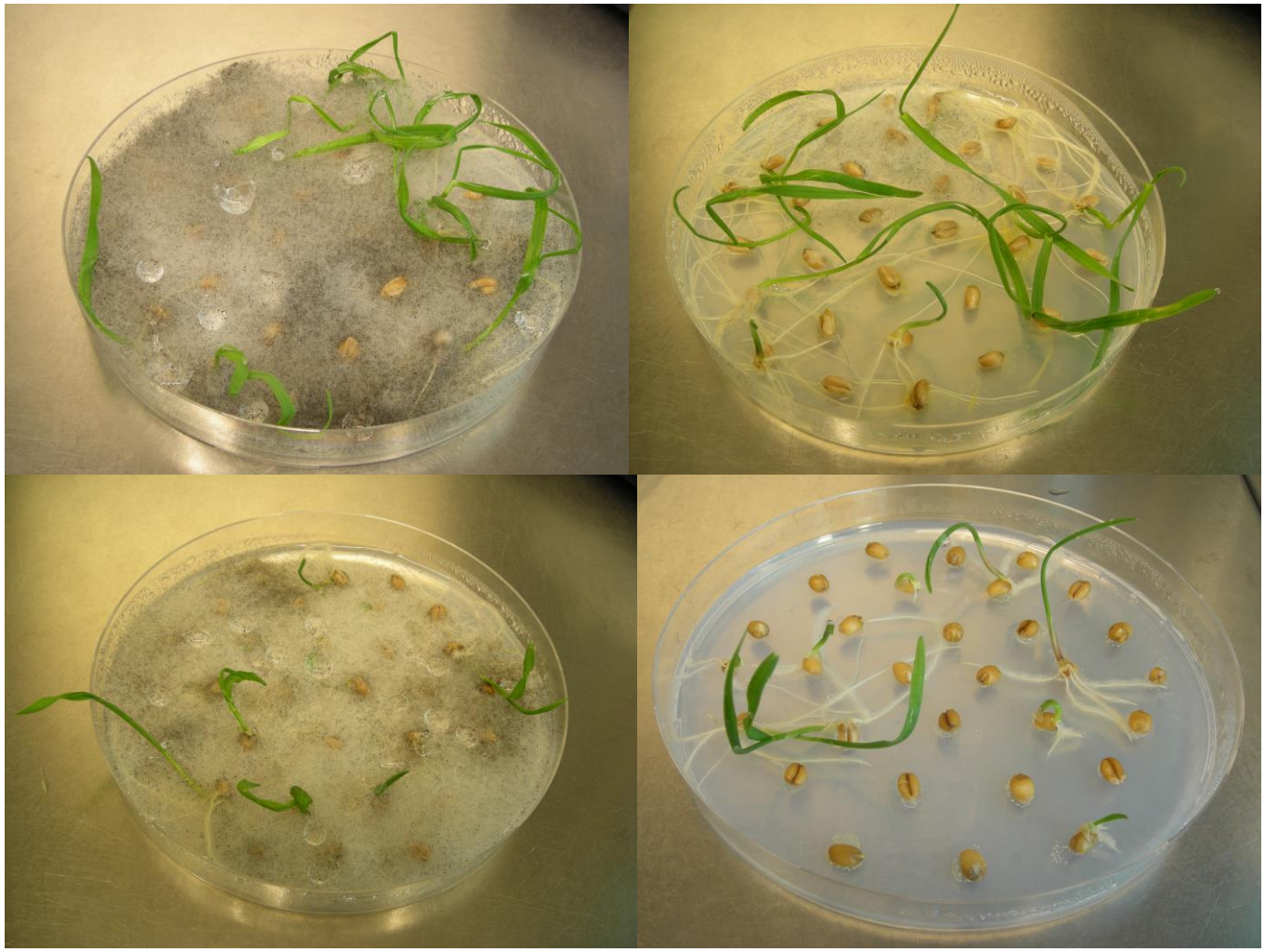
Reduced germination after storage under room temperature

Indicator species which are significantly more abundant under cold conditions

Isolation of the specific genus to find strains with the capability to improve germination

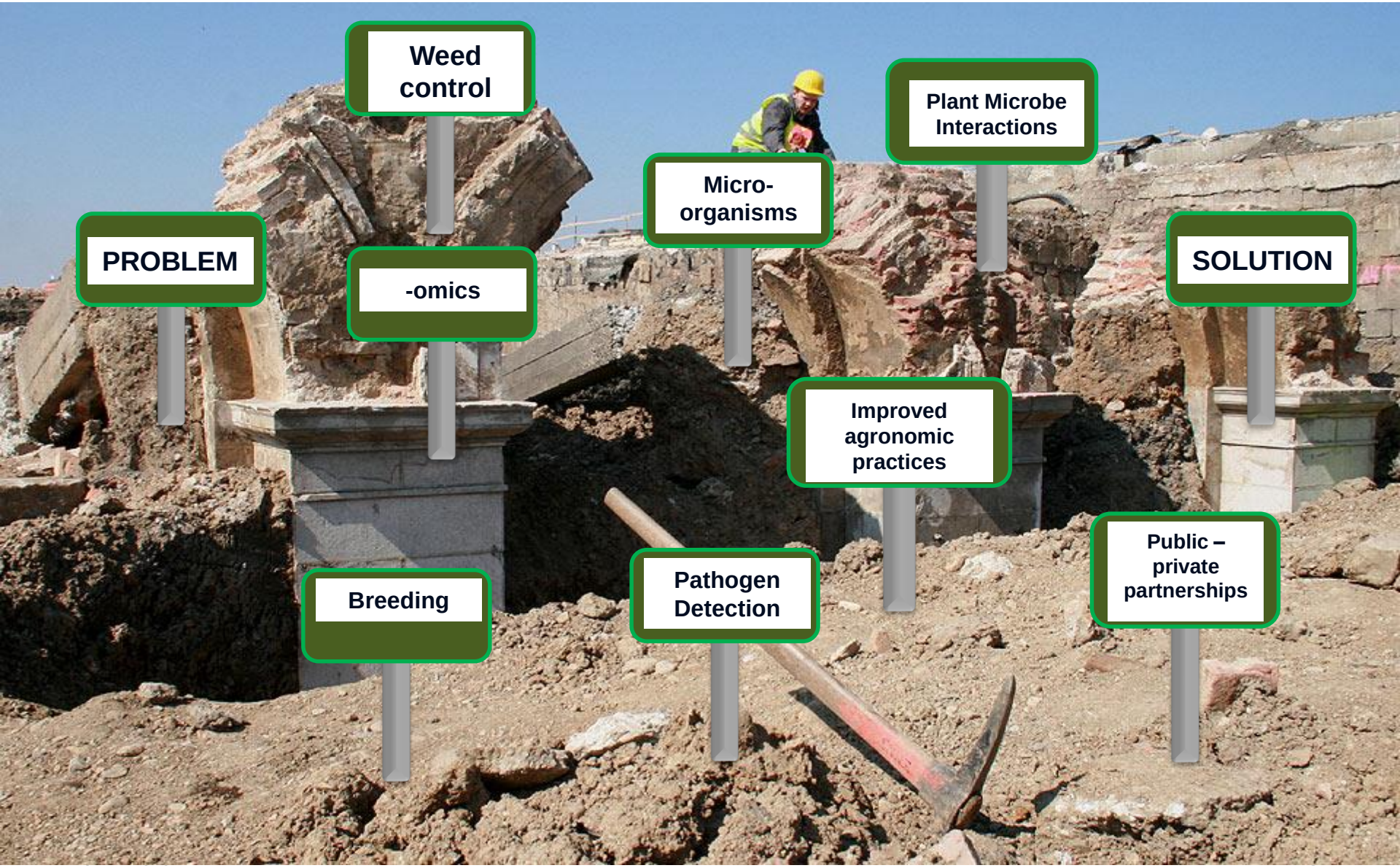
Seed endophytes of wheat as bio-control

Non-Treated **Treated**



Examples of fungal growth on agar plates, seed were not sterilized on two different genotypes

Ecological Engineering for agricultural sustainability



AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

Thank you very much for your attention

Birgit Mitter
Günter Brader
Günther Reichenberg
Stéphane Compant
Livio Antonielli
Abdul Samad
Katja Piller
Angela Sessitsch

miCROPe 2017: Microbe-assisted crop production – opportunities, challenges & needs

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C. Pieterse,
B. Reinhold-Hurek,
L. van Overbeek, G. Berg,
P. Bonfante, L. Weisskopf,
I. Sanders, A. Rodriguez,
Y. Moenne-Loccoz, A. Patel,
C. Preininger, J. Köhl,
D. Coleman-Derr,
R. Rodriguez, W. Ravensberg

Sessions:

- Successful microbial products
- Microorganisms for rural development
- New mechanisms involved in beneficial plant-microbe interactions
- Plant understanding and improvement of beneficial plant-microbe interactions
- The holobiont plant – multitrophic and microbiome interactions
- Application technologies and formulations
- Registration issues