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Agroscope

Universität Zürich UZH

microbiome management and soil ecological engineering for sustainable plant production

Marcel van der Heijden

With major contributions from: Franz Bender, Natacha Bodenhausen, Romina Demarmels, Julia Hess, Matthias Lutz, Klaus Schläppi & Cameron Wagg

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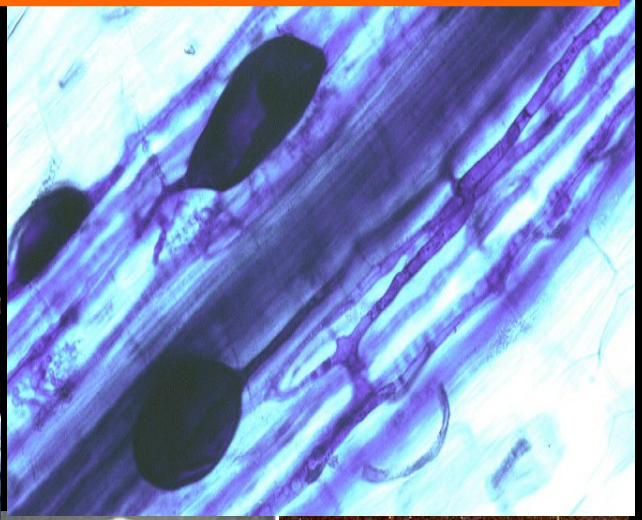
Global demand for food will increase with at least 60% in the coming 35 years – So far yield increases have been reached through fertilisers, pesticides and breeding: Can microbes help?

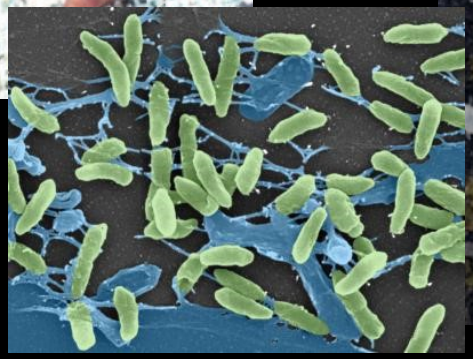
The microbiome: invisible friends and enemies……

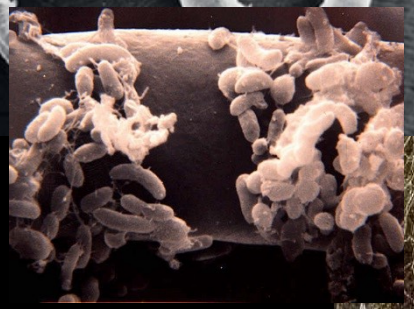
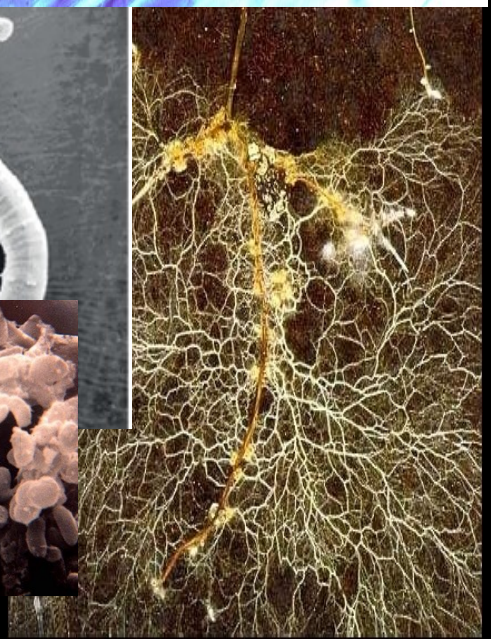
Soils are highly diverse:

1 gram of soil contains as many as 10^{10} bacteria, 6000 - 50.000 bacterial taxa and up to 100 metres of fungal hyphae



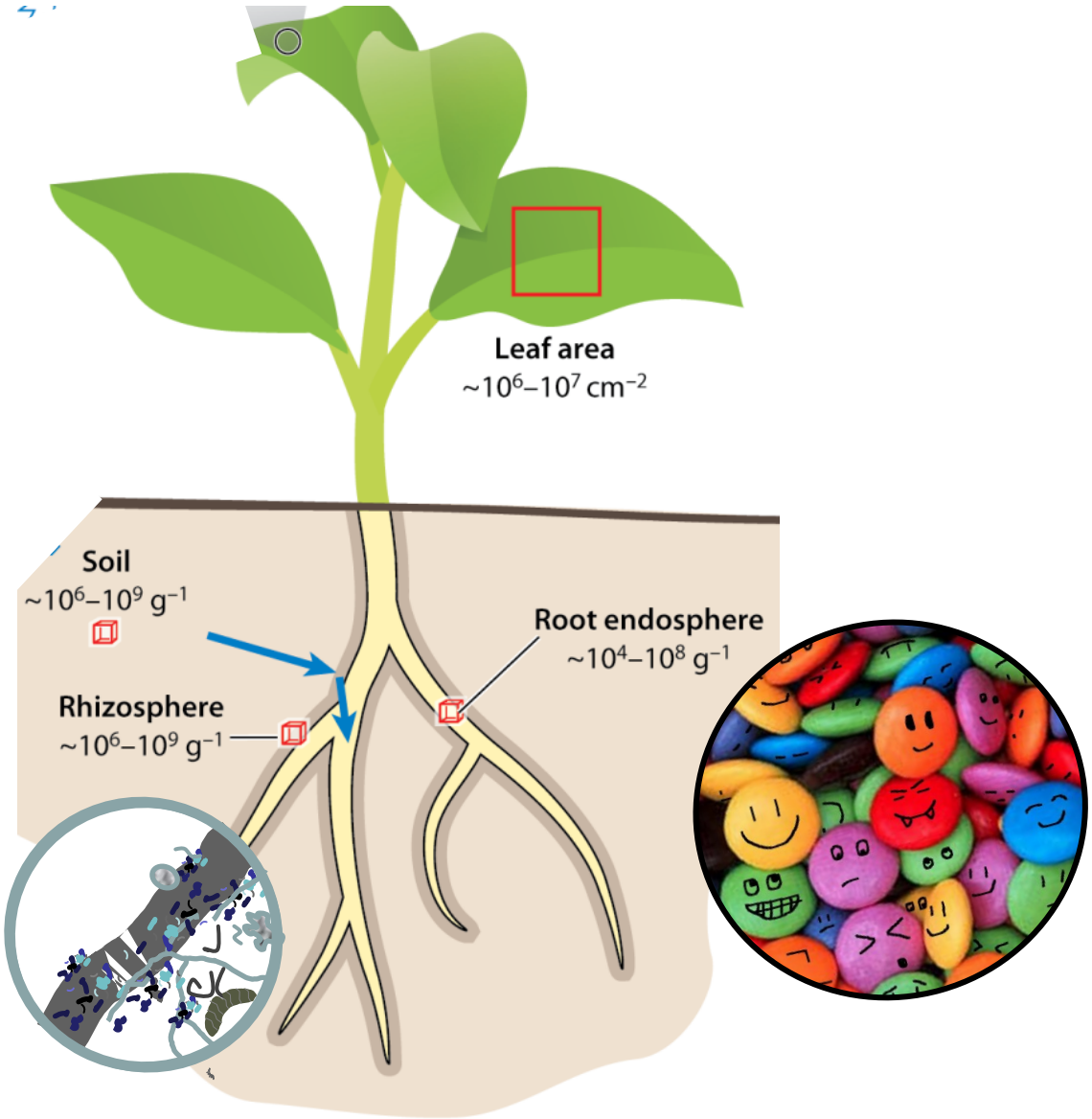




Fotos: Bardgett and van der Putten, 2014, Nature;
http://copalindia.blogspot.ch/2013/11/indigenous-soil-management-cost.htm;
http://www.eurekalert.org/multimedia/pub/47157.phpl

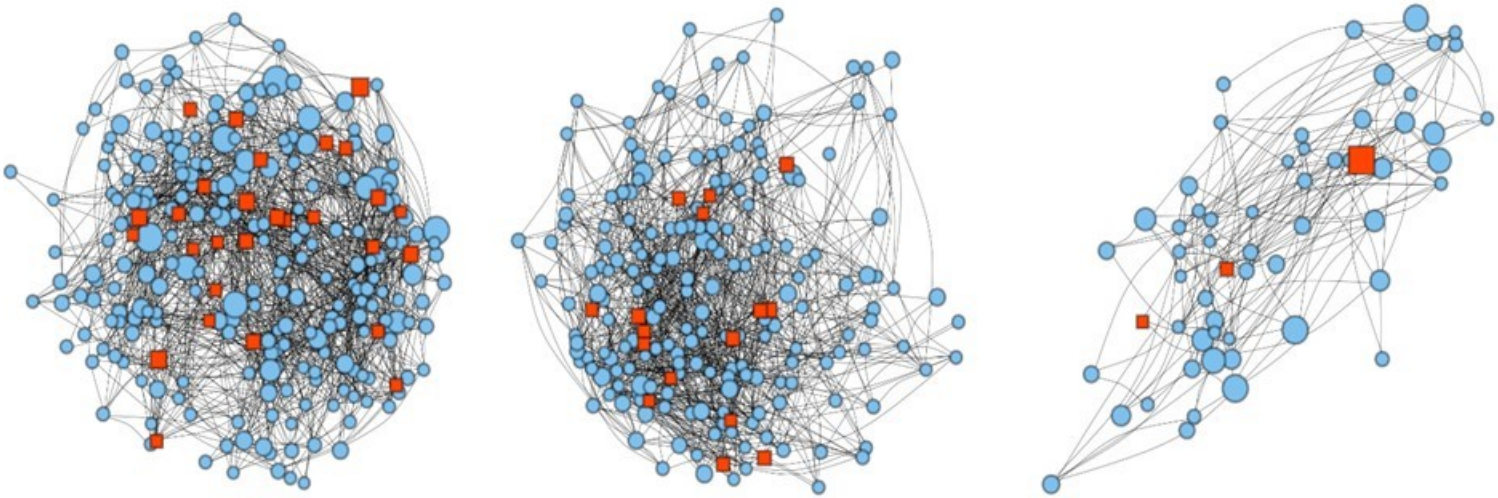
A jungle under our feet!!



Bulgarelli *et al.* (2013), Annu. Rev. Plant Biol. 64:807-38

Microbiomes consist of millions of bacteria, fungi and protozoa that directly and indirectly interact with each other – they are organised in microbial networks

Association network

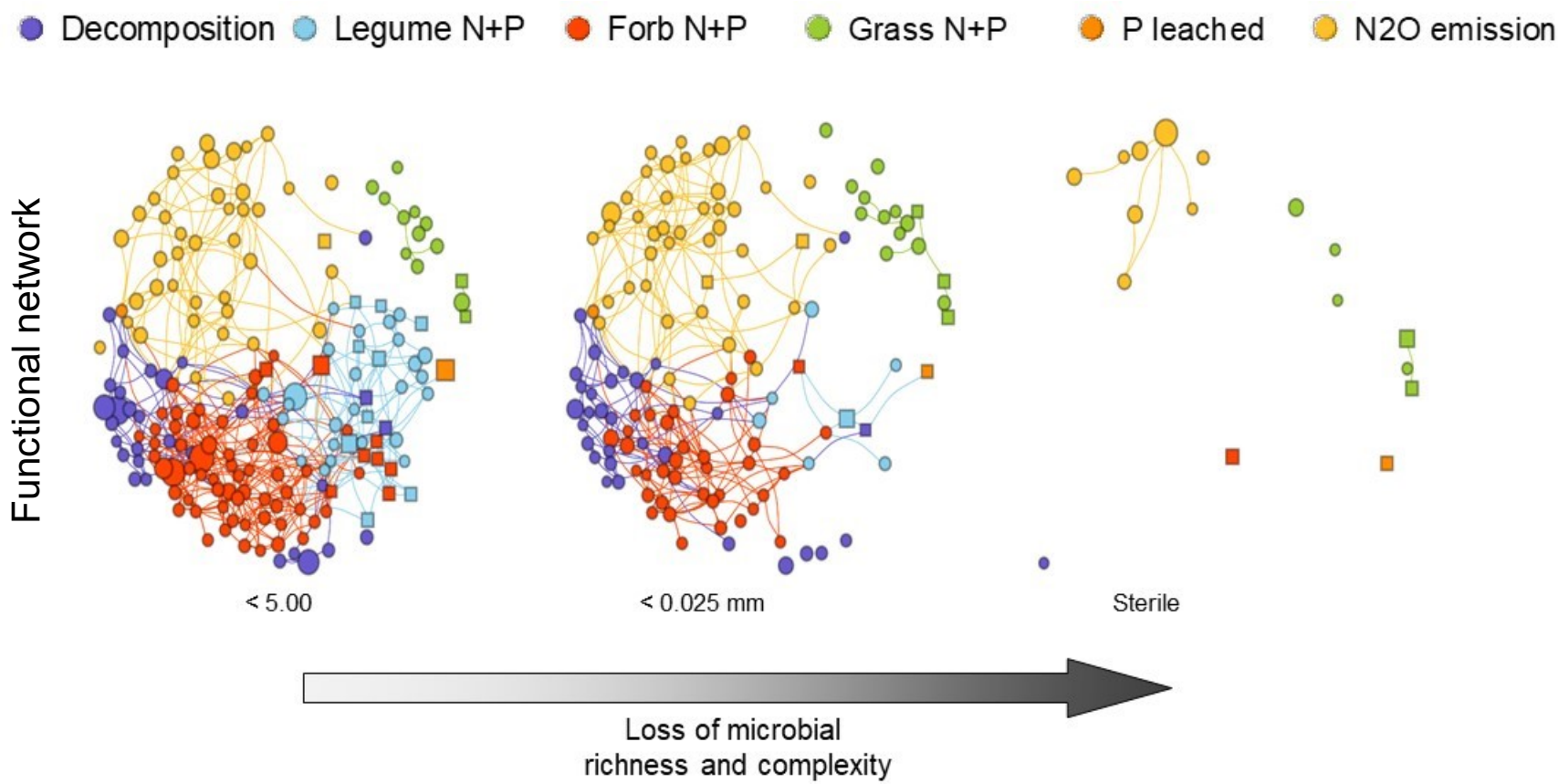


species rich network
strongly interlinked

species poor network
low network complexity

Wagg et al. 2019, Nature Communications

Different microbes provide different services and disservices (e.g. disease)



Wagg et al. 2019, Nature Communications

Soil ecological engineering and microbiome management – promoting the right microbes

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There are two strategies for soil ecological engineering and microbiome management:

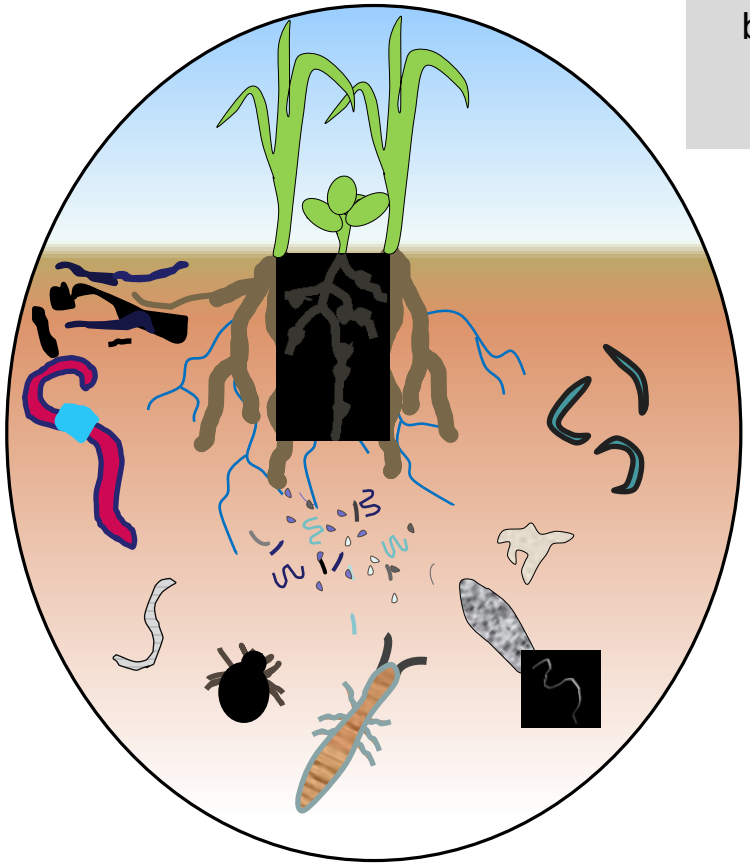
Indirect approach

Creating conducive conditions for beneficial soil life

Direct approach

Targetted stimulation of beneficial soil biota that provide particular ecosystem services

Which cultivars and management practices promote/ make use of beneficial soil life



adding beneficial (non native) soil biota (e.g. mycorrhiza)

Bender, Wagg & van der Heijden (2017) *TREE*

examples of soil beneficials:

-Nitrogen fixing bacteria fix up to 300 kg N per hectare and year
-Mycorrhizal fungi supply P to plants (30% to 90% of plant P)

van der Heijden et al. (1998), Nature
van der Heijden et al. (2008), Ecology Letters

Biologicals: a rapidly growing market

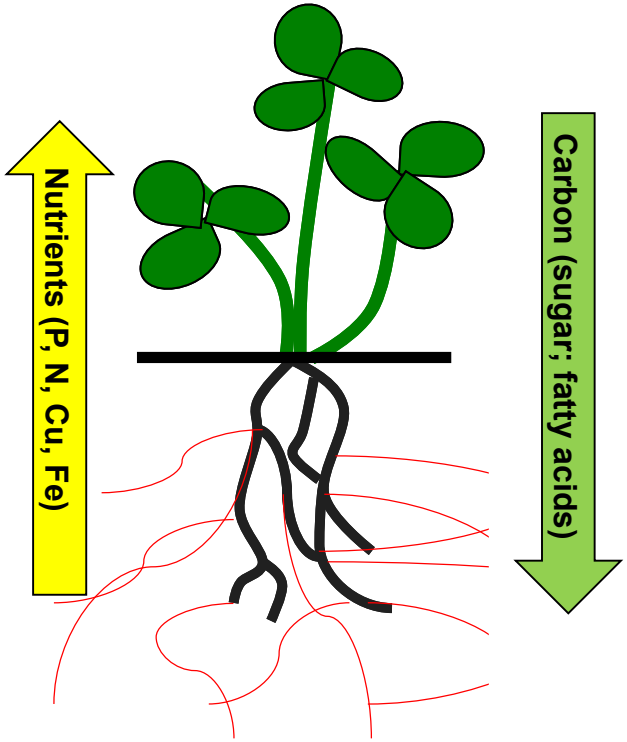
- Pesticides = €100 billion

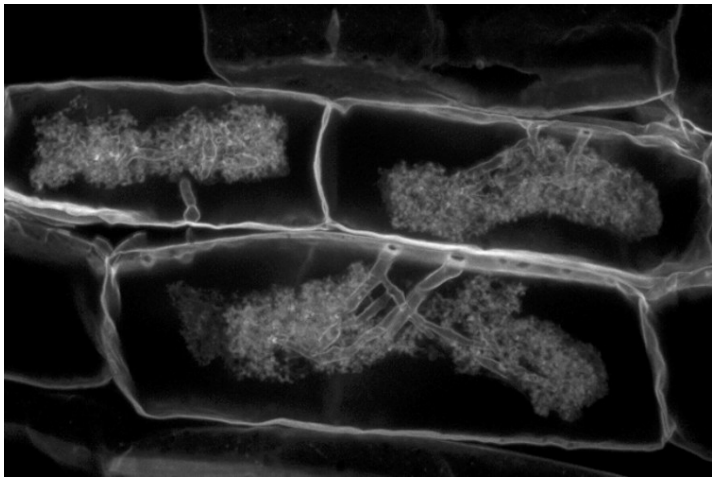
- Biologicals: +15%/jr
- = €10 billion in 2020

- Many companies (also big ones);
- Many Start-Ups

Arbuscular mycorrhizal fungi (AMF)

- Probably the most ancient and abundant plant symbionts on Earth.
- Up to 90% of plant P and plant N is acquired by mycorrhizal fungi
- Arbuscular mycorrhizal fungi associate with most major crops including arable crops (potato, cereals) and vegetables (e.g. salad, tomato, carrot)





Smith & Read 2008, Mycorhizal Symbiosis
van der Heijden et al. 1998, Nature
Jiang et al. 2017, Science
Luginbuehl et al. 2017, Science

Shabana Hoosein

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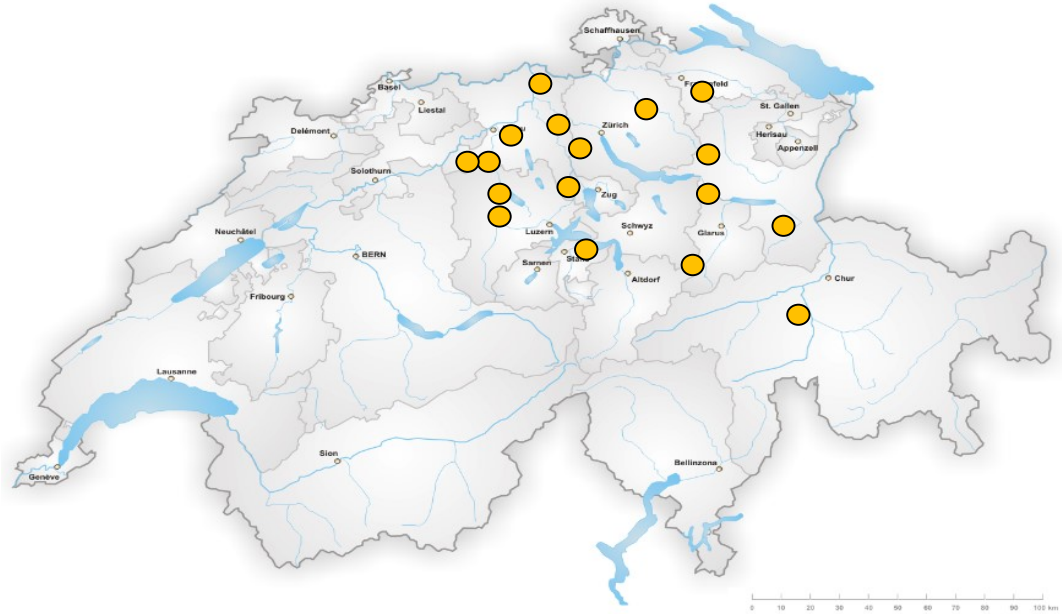
is it possible to enhance plant yield by inoculating with biologicals (we focus on AMF)?



16 plots per field

1 plot: 2 rows à 1m

half of the plots inoculated with *Rhizoglomus irregulare*

half with a control inoculum

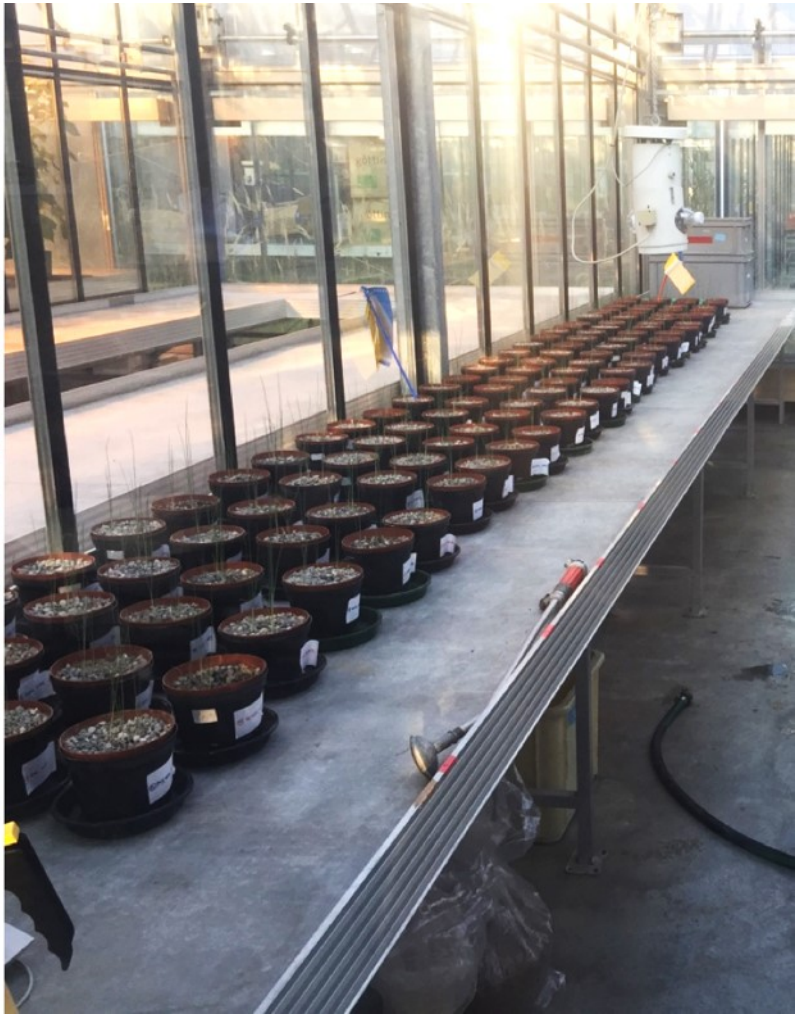
Field inoculation works…but not always

Julia Hess

Natacha Bodenhausen

Unpublished results: Natacha Bodenhausen, Julia Hess, Klaus Schläppi & myself
See: Bender et al. 2019 AEE; Schlaeppi et al. 2016, New Phytologist;
Köhl et al. 2016, Plant, Cell & Environment

Are we ready for field application? testing 15 commercial AMF products from various countries in Europe, including Switzerland



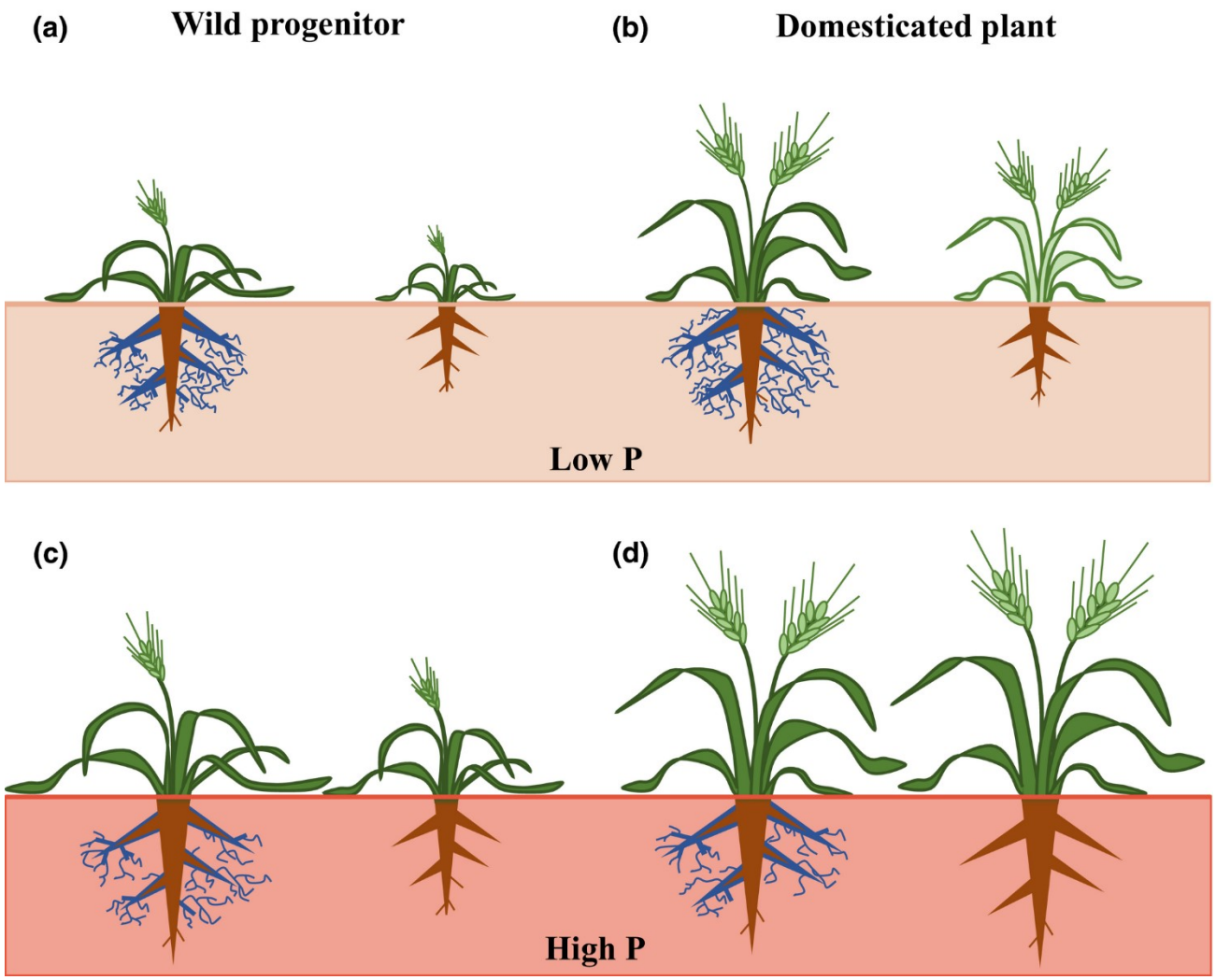
>50% of commercially available AMF products apparently contain no active AMF….

Romina Demarmels & van der Heijden, Unpublished results

>50% of commercially available AMF products do not promote plant growth in our experimental model system with leek

AMF NM
(G.i)

Plant genotype matters – modern crop varieties generally benefit less from AMF



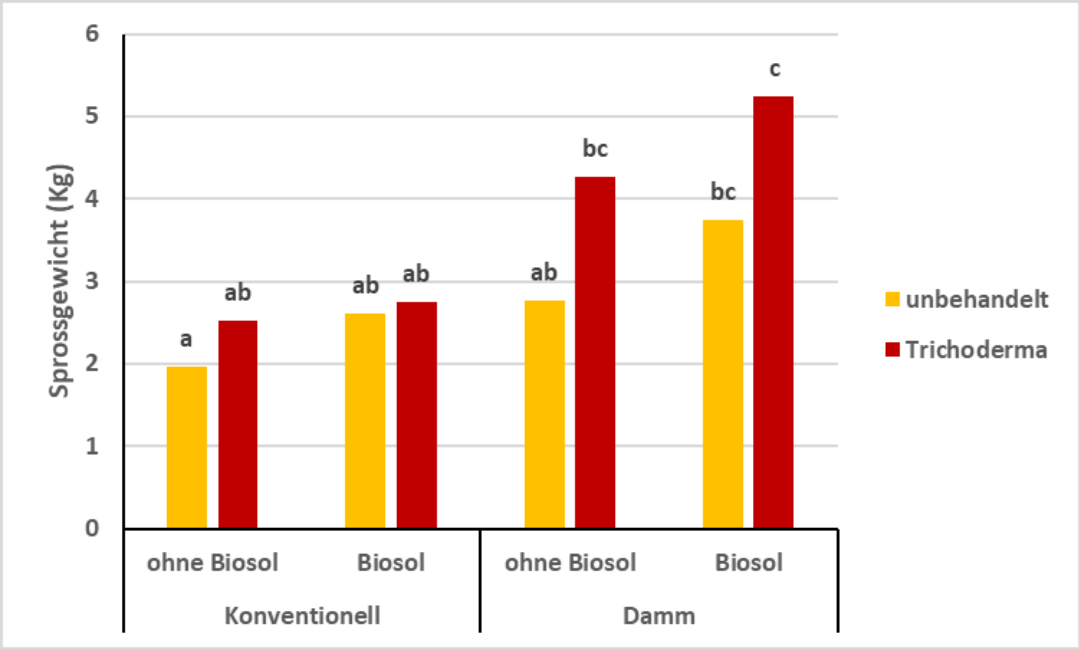
Martin-Robles et al. (2018) New Phytologist

The plant and soil microbiome: an enormous reservoir for undiscovered beneficials

Plasmodiophora brassicae (Kohlherni; Hernie du chou)

Trichoderma harzianum

Biologicals in vegetable farming: *Trichoderma* as a tool to combat clubroot damage in cabbage



Broccoli field

Unpublished results: Matthias Lutz, Agroscope

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Conclusions

- The addition of biologicals such as AMF and *Trichoderma* have potential to promote plant growth and reduce the reliance on fertilisers and pesticides
- Results can be variable and depend on crop, crop genotype, soil type, management and other factors.
- Not all available products are reliable and well tested.
- The soil and plant microbiome is extremely diverse and a huge reservoir for potential biologicals. It is still poorly understood which microbes (or microbial consortia) are beneficial for promoting plant growth. We need to provide solutions and applications that can be used to boost plant productivity under field conditions.

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STIFTUNG MERCATOR SCHWEIZ

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