Nützlinge nutzbar machen:

Mykorrhizapilze in der Landwirtschaft

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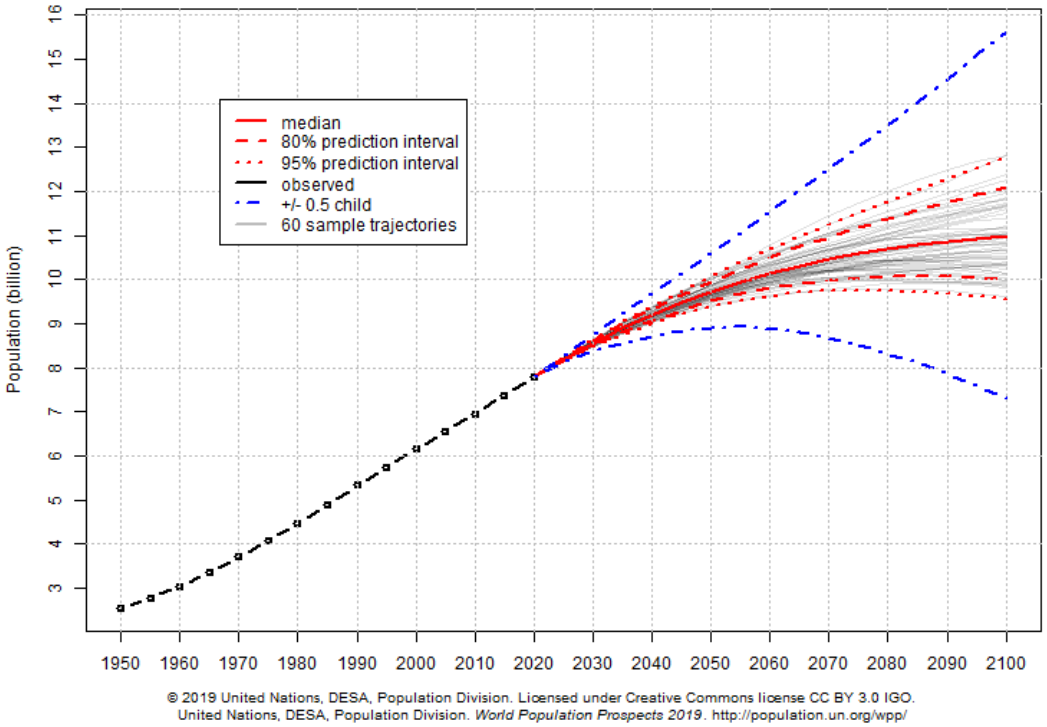
11. Nachhaltigkeitstagung Agroscope
25.01.2024

Food security and agricultural intensification

Growing world population → Demand for food → Agricultural intensification



Source: greentumble.com

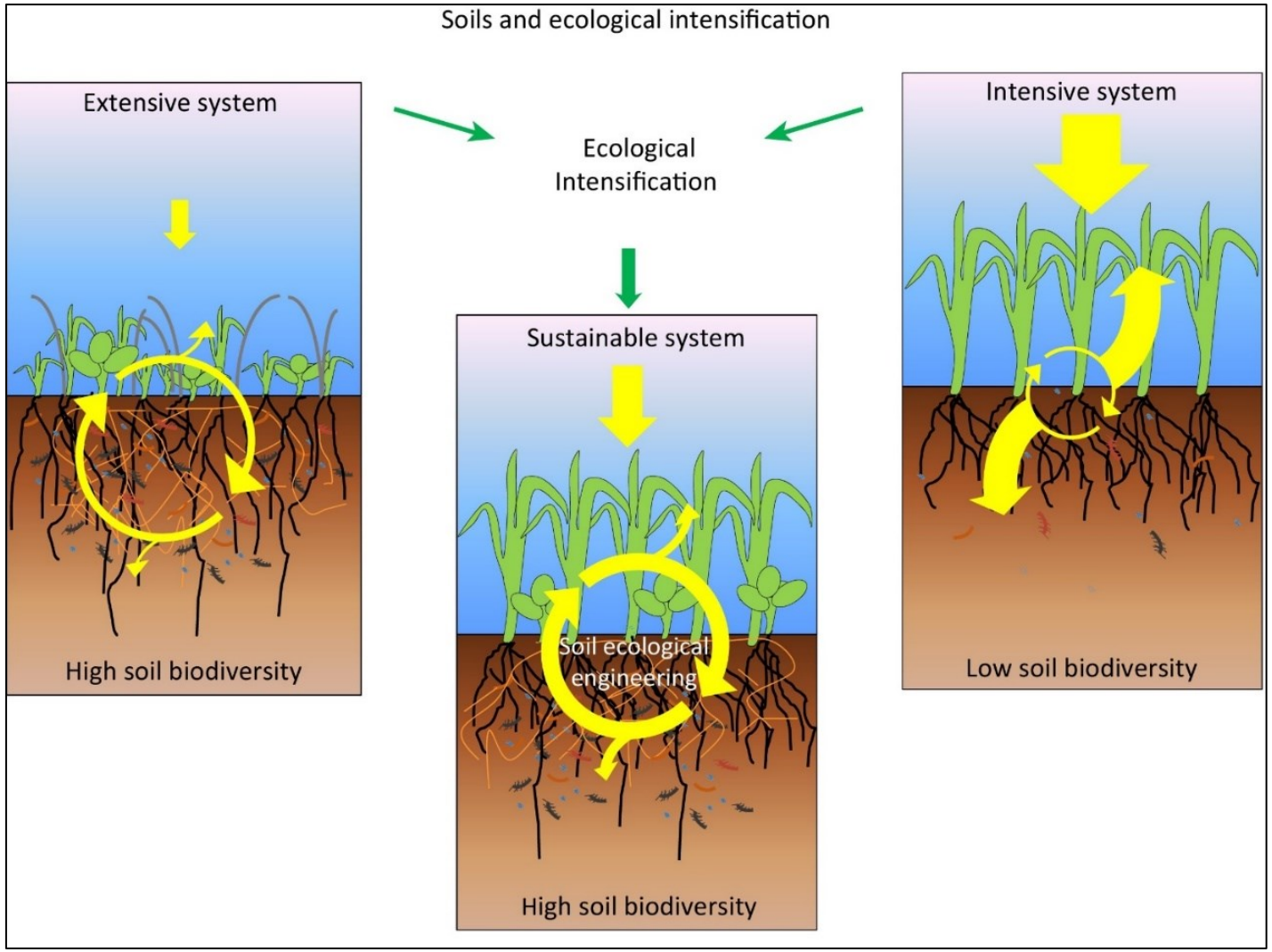
Excess use of fertilizers and pesticides

Source: phosphorusfutures.net

Phosphate resources are finite

Food security ⚡ Environmental costs

Microbiome management to increase agricultural sustainability



Bender et al (2016) Trends in Ecology & Evolution

Arbuscular mycorrhizal fungi (AMF)

- Phylum Glomeromycota
- Symbiosis with ~80% of terrestrial plants including most major crops
- Exchange of carboydrates for nutrients

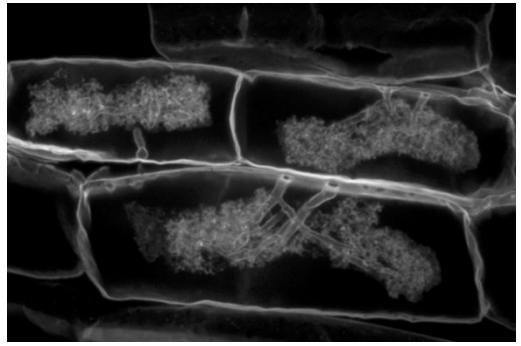


Photo courtesy of Ryan Geil, published with kind permission from Peterson et al. (2004) and NRC press, © Canadian Science Publishing or its licensors

- AMF

+ AMF

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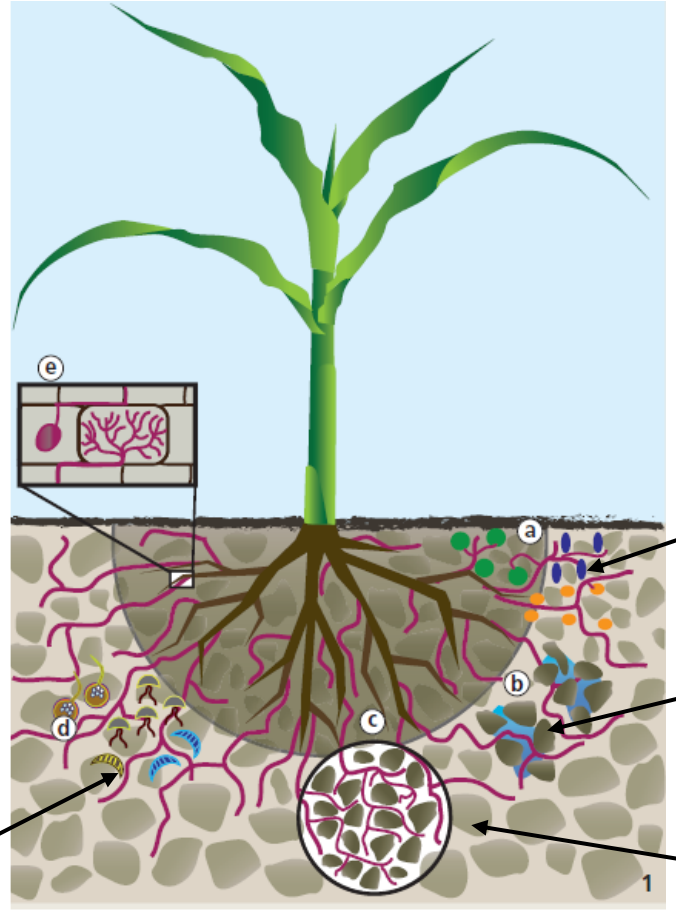
AMF can improve…



Nutrient uptake (P, N, Co, Zn)

Drought tolerance

Disease resistance

Soil structure

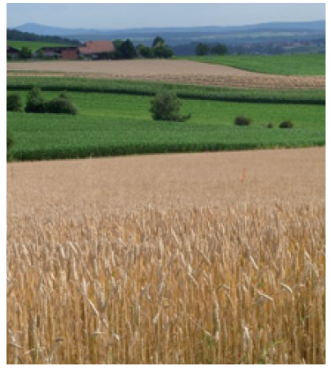
Köhl & van der Heijden, 2016. Agridea.

Two strategies to promote AMF

Indirect: Favourable management practices

Fertilizer reduction

Crop rotation



No/reduced tillage

Cover crop

Köhl & van der Heijden, 2016. Agridea.

Direct: Field inoculations

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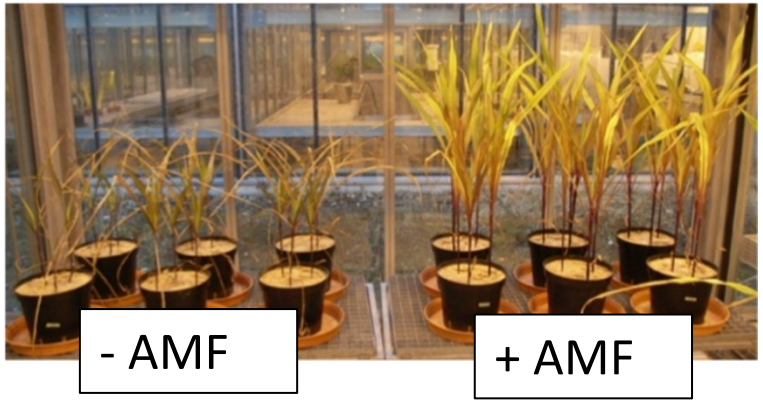
Rhizoglomus irregulare SAF22



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Issue: Field inoculations have a high potential but are unreliable

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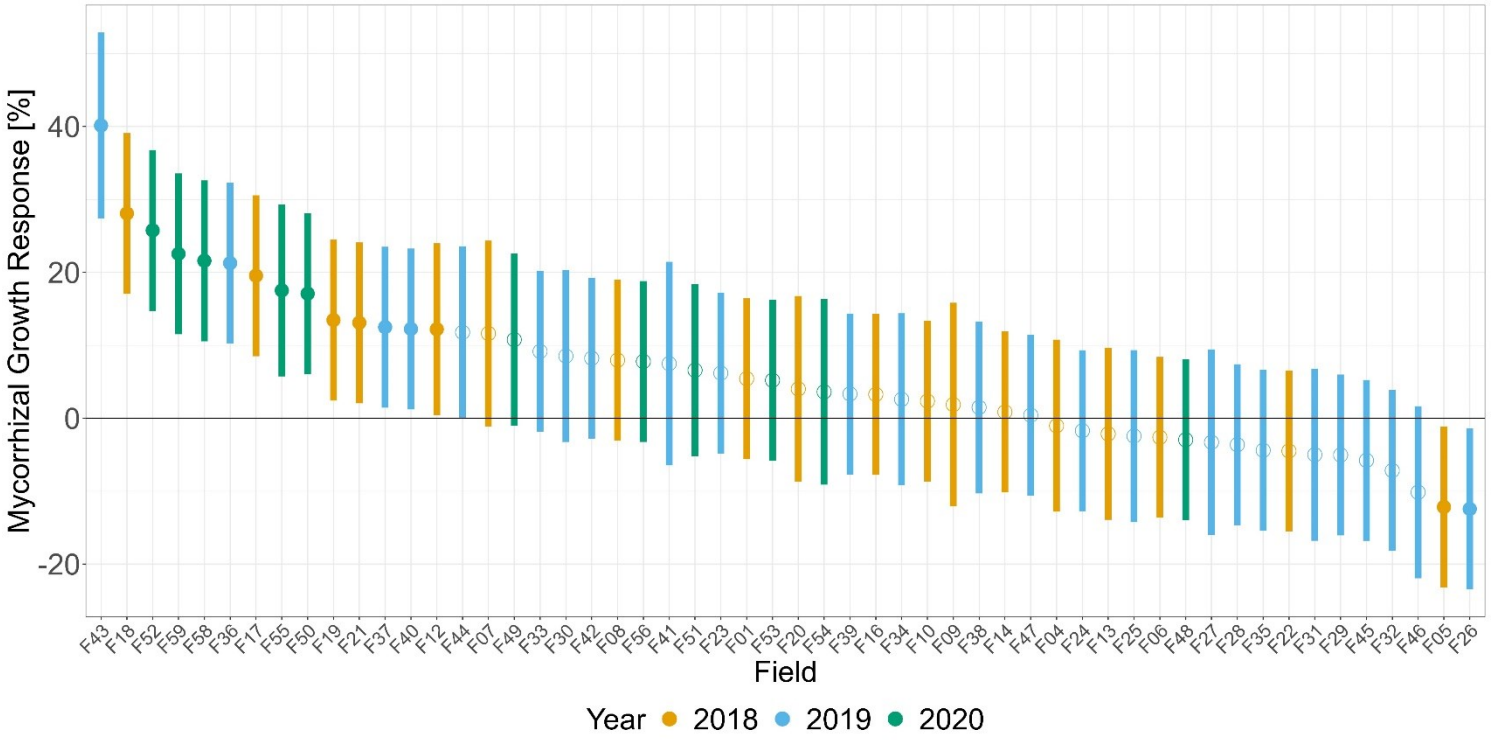
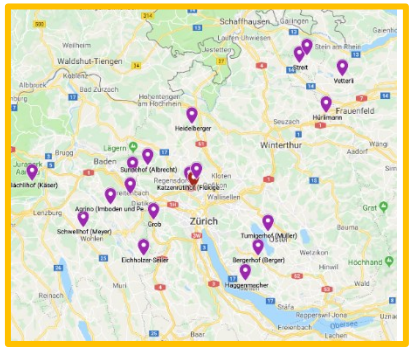
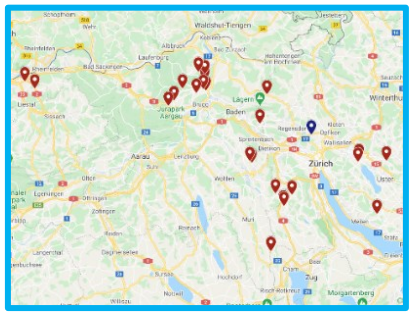


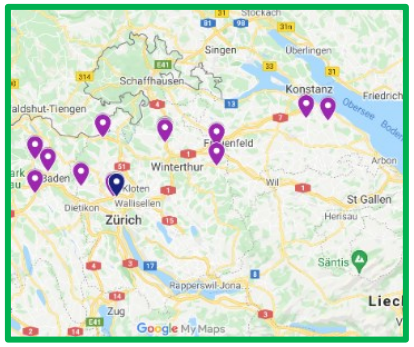
2018:
22 fields



2019:
25 fields



2020:
12 fields



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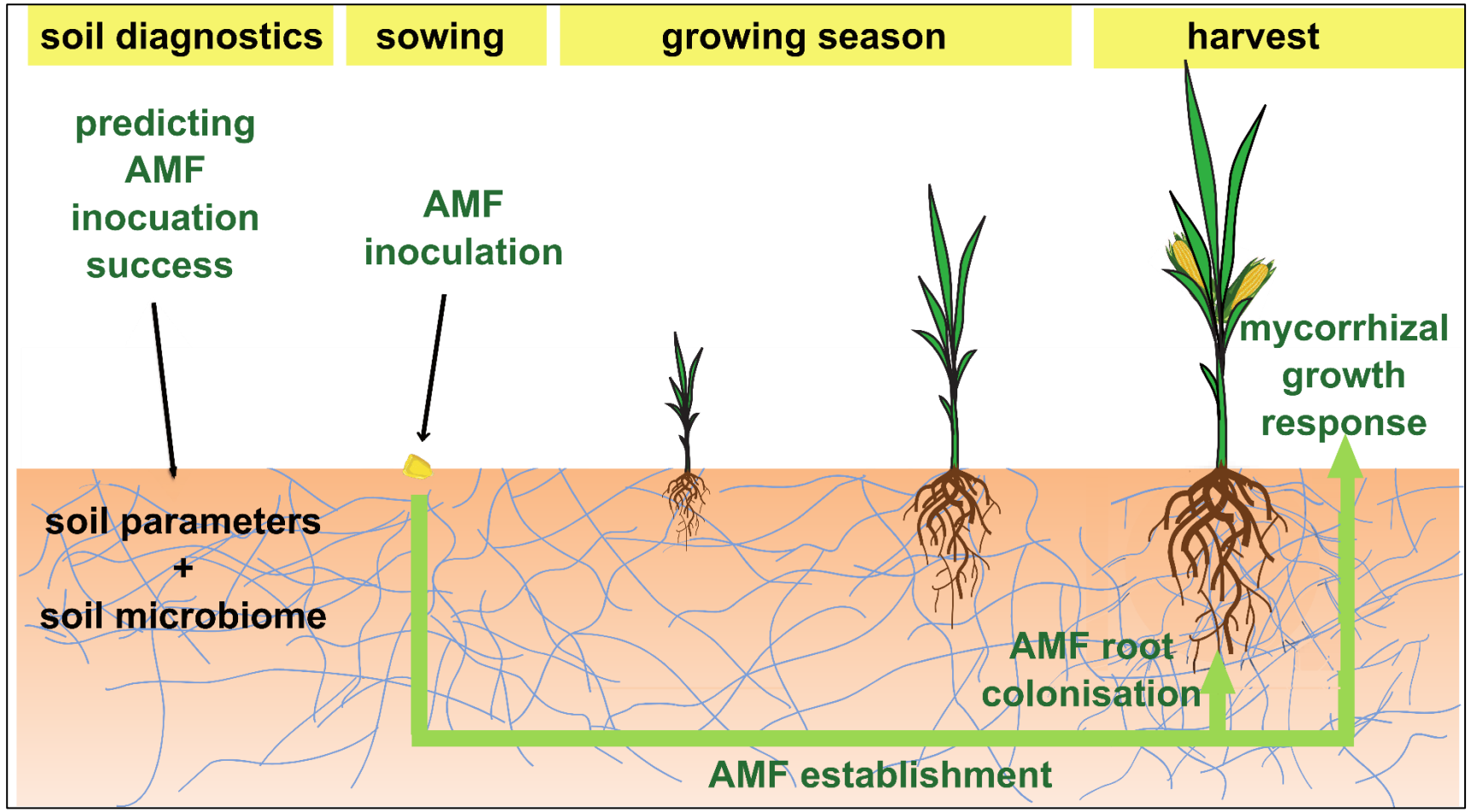
Natacha
Bodenhausen

Klaus
Schläppi

Alain
Valzano-Held

Julia
Hess

Experimental set-up of the field inoculation trials



Lutz S. et al. “Soil microbiome indicators can predict crop growth response to large-scale inoculation with arbuscular mycorrhizal fungi." *Nature Microbiology* 8.12 (2023): 2277-2289.

Can we predict the mycorrhizal growth response?

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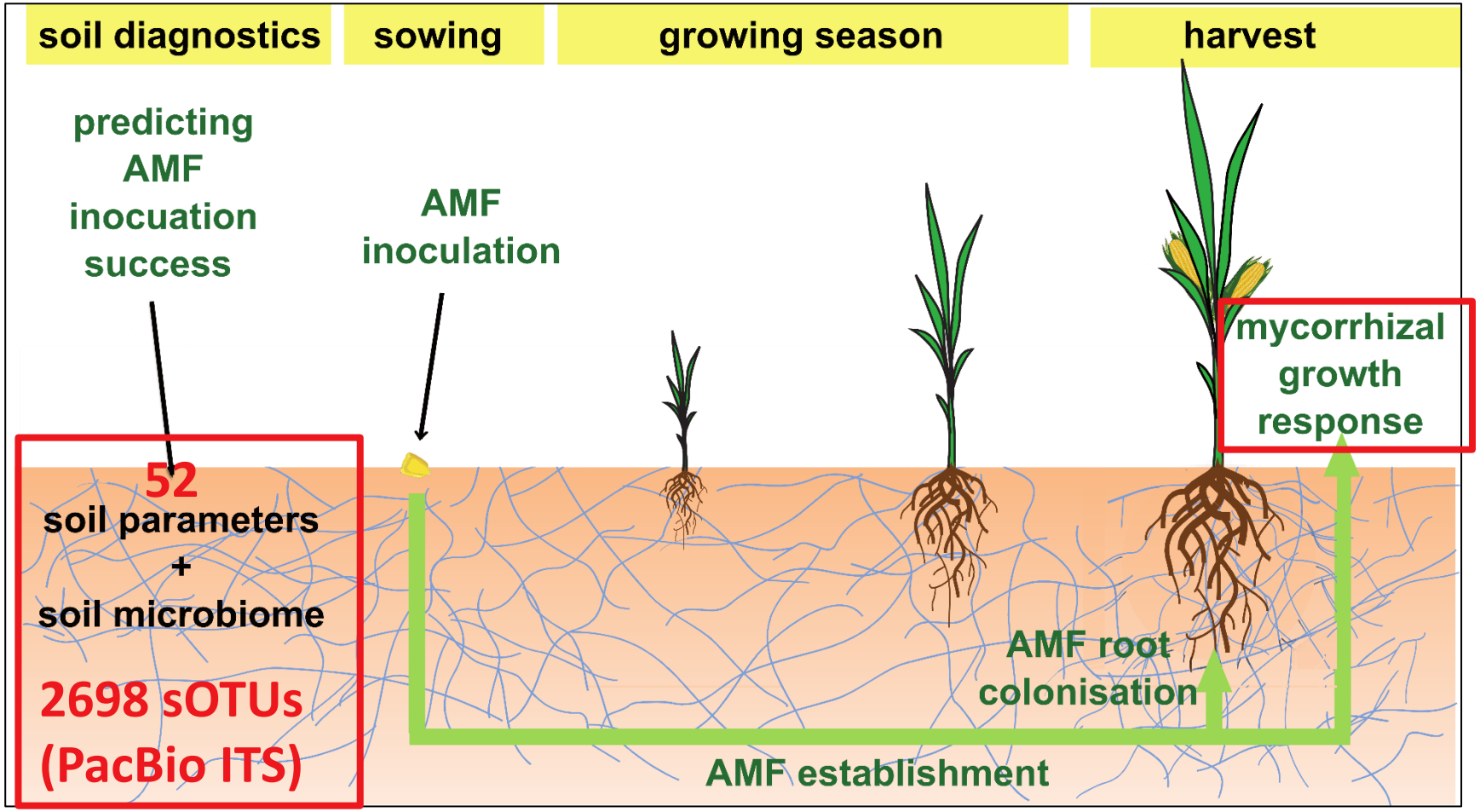
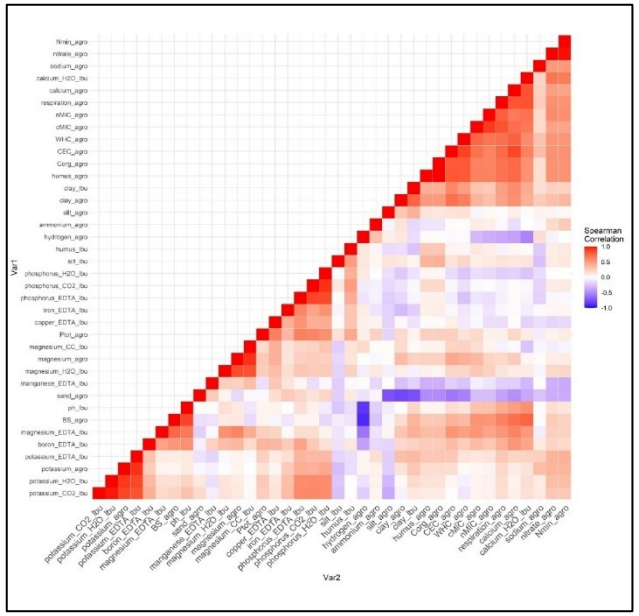


MGR ~ soil parameters + soil microbiome?

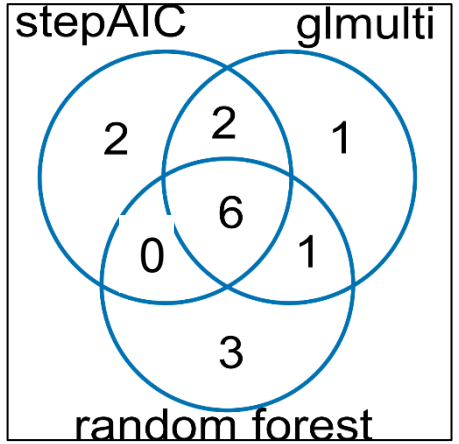
Predictor selection: MGR ~ soil parameters

52 parameters → **38 parameters** → **22 parameters** → **15 parameters**

- Ptot_agro
- BS_agro
- CEC_agro
- sodium_agro
- potassium_agro
- magnesium_agro
- calcium_agro
- hydrogen_agro
- sand_agro
- silt_agro
- clay_agro
- humus_agro
- Corg_agro
- respiration_agro
- cMIC_agro
- nMIC_agro
- WHC_agro
- nitrate_agro
- ammonium_agro
- Nmin_agro
- Ctot_agro
- Ntot_agro
- clay_lbu
- silt_lbu
- humus_lbu
- ph_lbu
- phosphorus_CO2_lbu
- potassium_CO2_lbu
- magnesium_CC_lbu
- phosphorus_EDTA_lbu
- potassium_EDTA_lbu
- magnesium_EDTA_lbu
- manganese_EDTA_lbu
- boron_EDTA_lbu
- copper_EDTA_lbu
- iron_EDTA_lbu
- calcium_EDTA_lbu
- zinc_EDTA_lbu
- phosphorus_H2O_lbu
- potassium_H2O_lbu
- calcium_H2O_lbu
- magnesium_H2O_lbu
- boron_H2O_lbu
- iron_H2O_lbu
- sodium_H2O_lbu
- nitrate_H2O_lbu
- ammonium_H2O_lbu
- P_olsen_lbu
- respiration_lbu
- slan_lbu
- vast_lbu
- fertility_lbu



r>0.8, r<-0.8

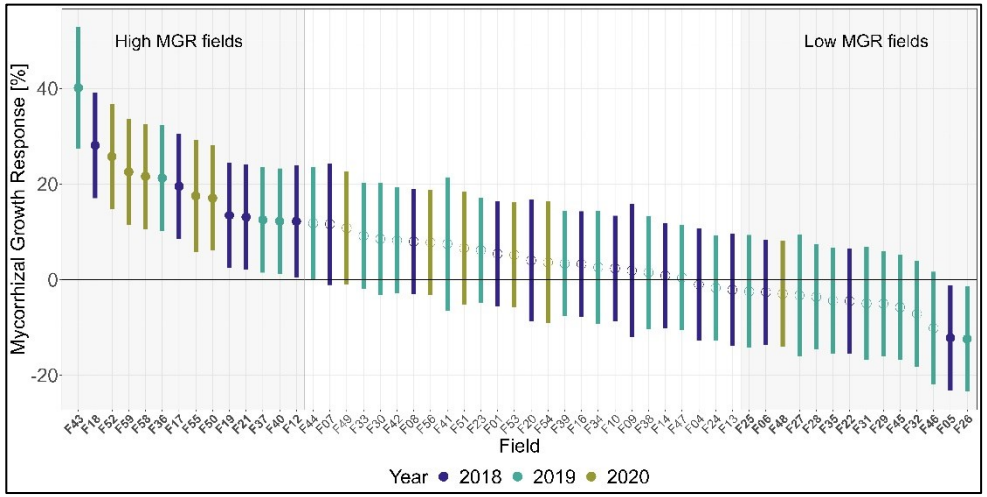


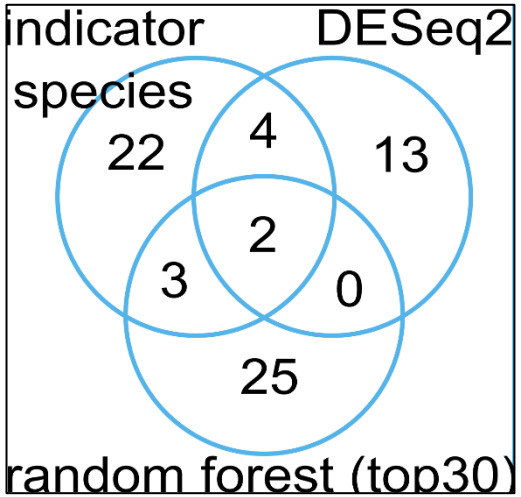
magnesium(EDTA)
magnesium(H2O)
manganese
Nmin
iron
cMIC
phosphorus(H2O)
ammonium
Corg
sand
silt
Ptot
boron
clay
pH

Predictor selection: MGR ~ soil fungal OTUs

2698 sOTUs → **13 sOTUs**

High vs low MGR





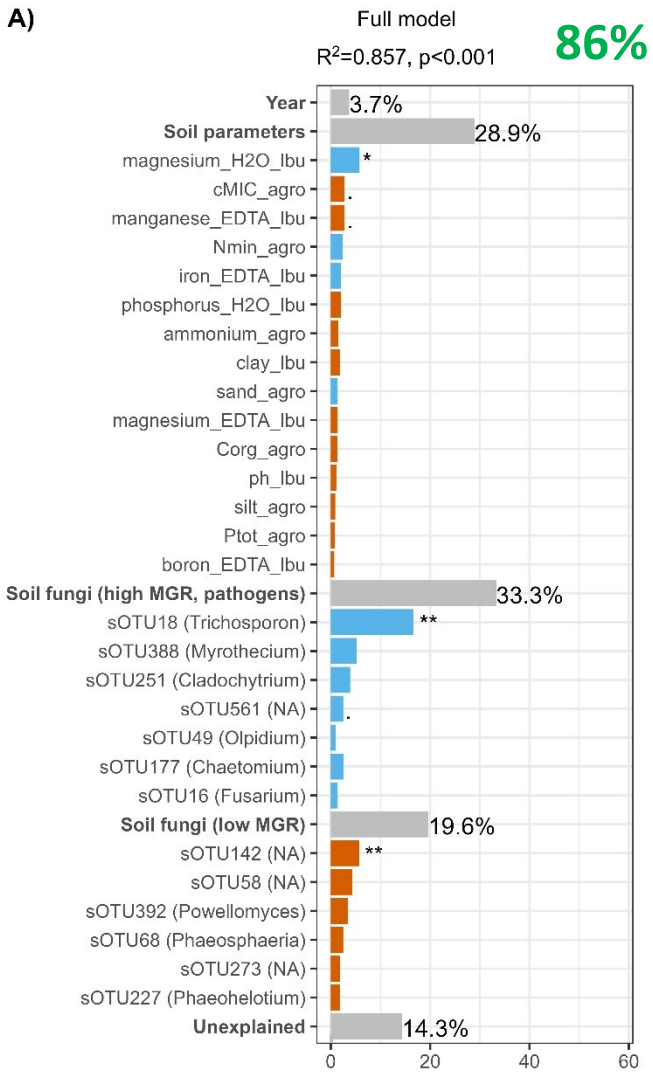
High MGR:

- sOTU16: *Fusarium equiseti*
- sOTU18: *Trichosporon* sp.
- sOTU49: *Olpidium brassicae*
- sOTU177: *Chaetomium* sp.
- sOTU251: *Chladochytrium* sp.
- sOTU388: *Myrothecium* sp.
- sOTU561: No blast hit

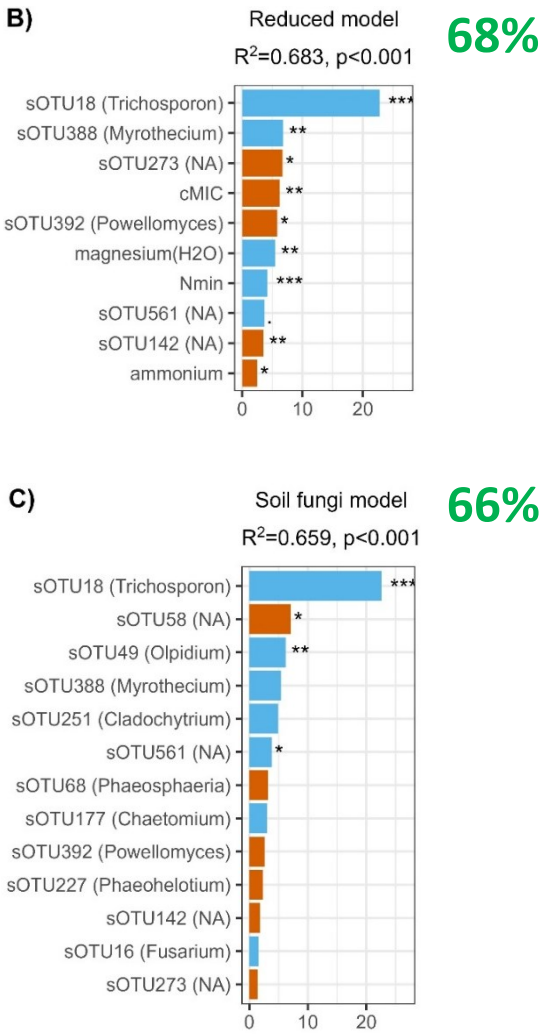
Low MGR:

- sOTU58: No blast
- sOTU68: *Phaeosphaeria* sp.
- sOTU142: No blast hit
- sOTU227: *Phaeohelotium* sp.
- sOTU273: No blast hit
- sOTU392: *Powellomyces sp.*

Multiple linear regression models explain variation in MGR



- Soil microbiome more important than soil physico-chemical parameters in predicting maize growth response to AMF inoculation
- Abundance of "pathogenic" fungi best predicted (33%) AMF inoculation success



negative positive

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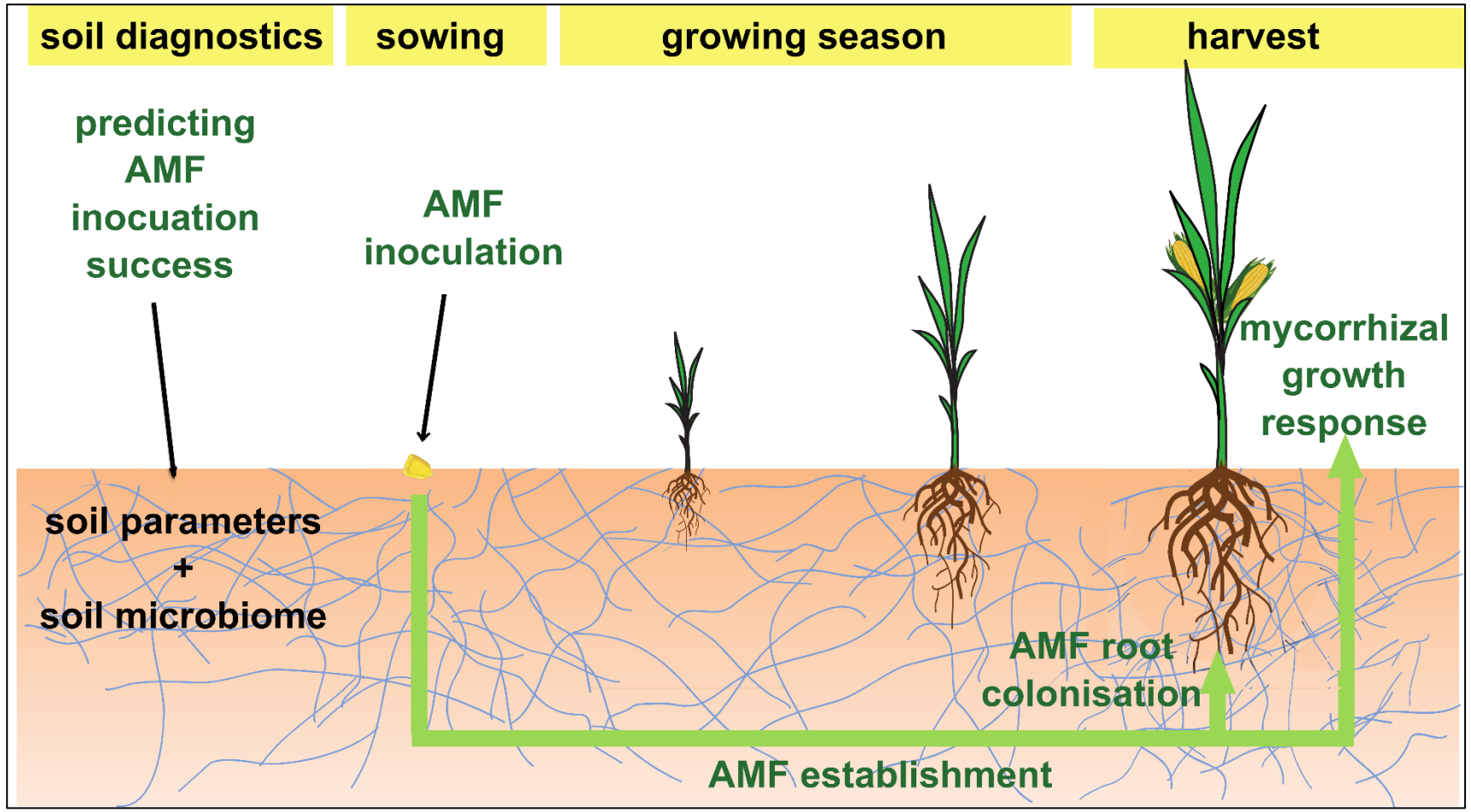
Experimental set-up of the field inoculation trials



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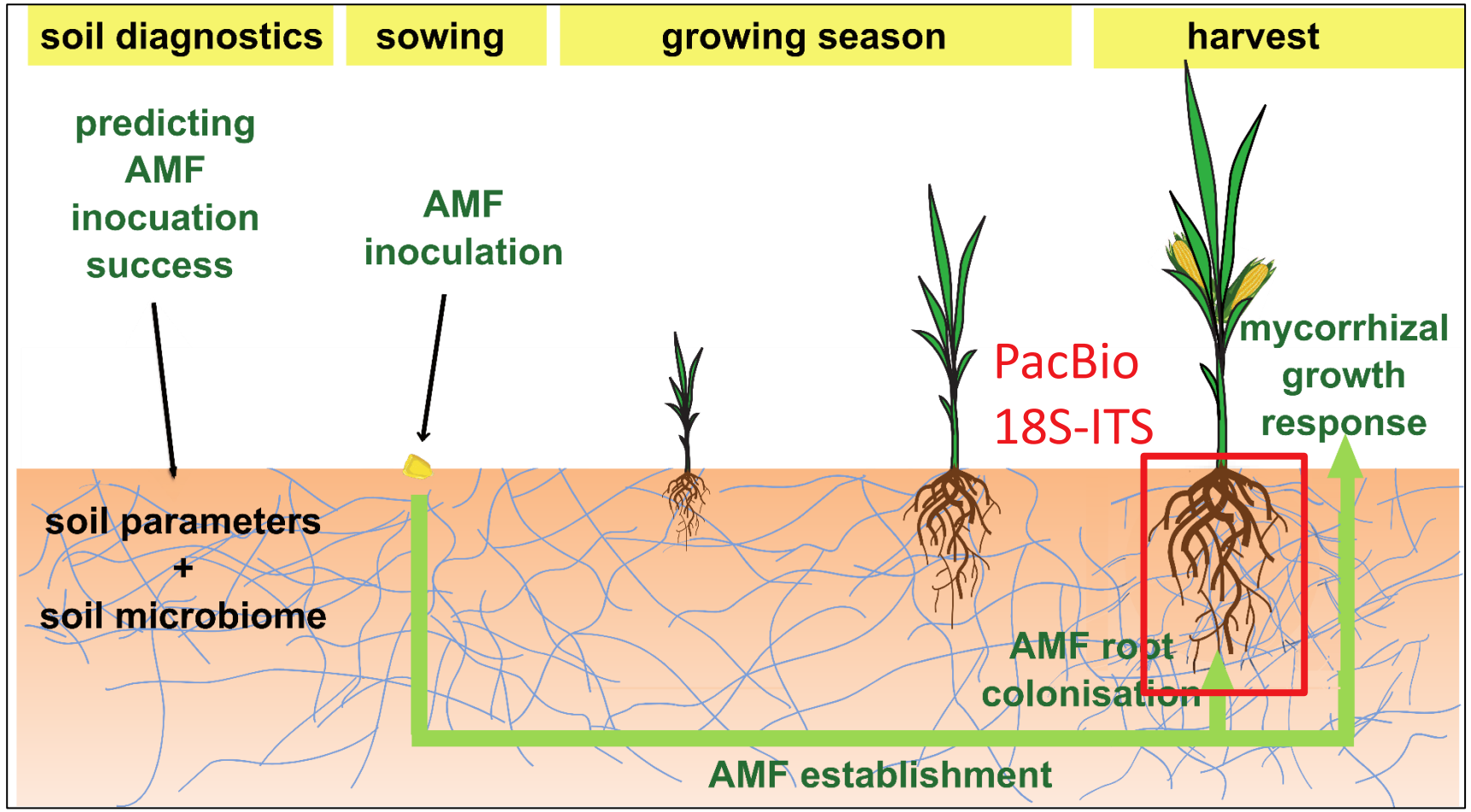

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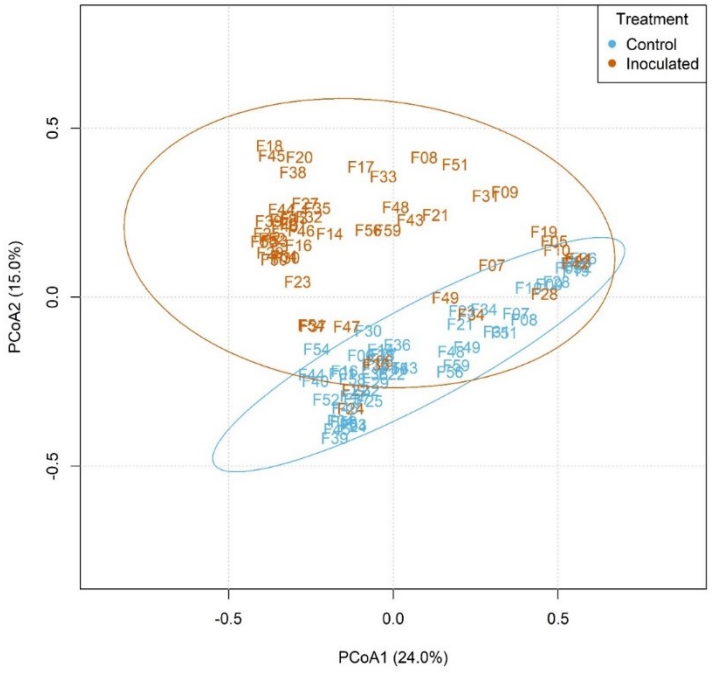
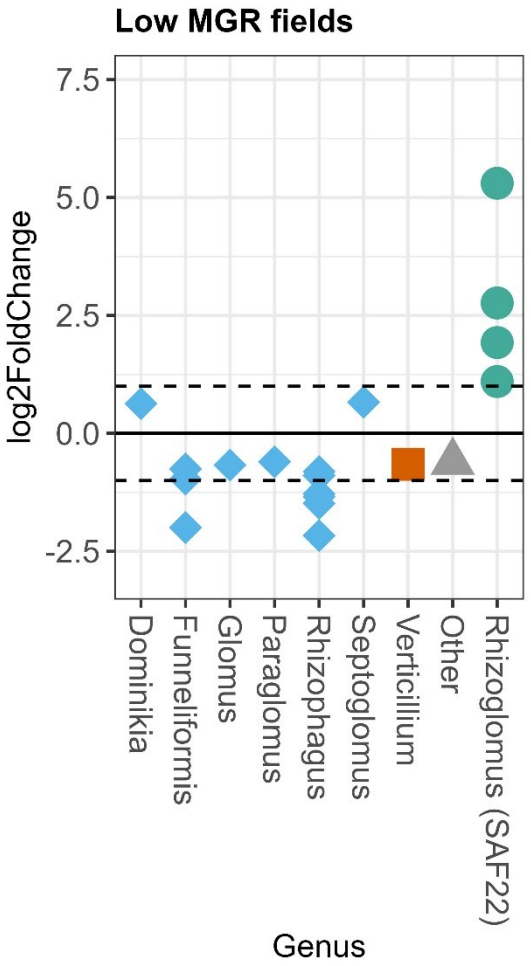
Root microbiome composition and differentially abundant rOTUs

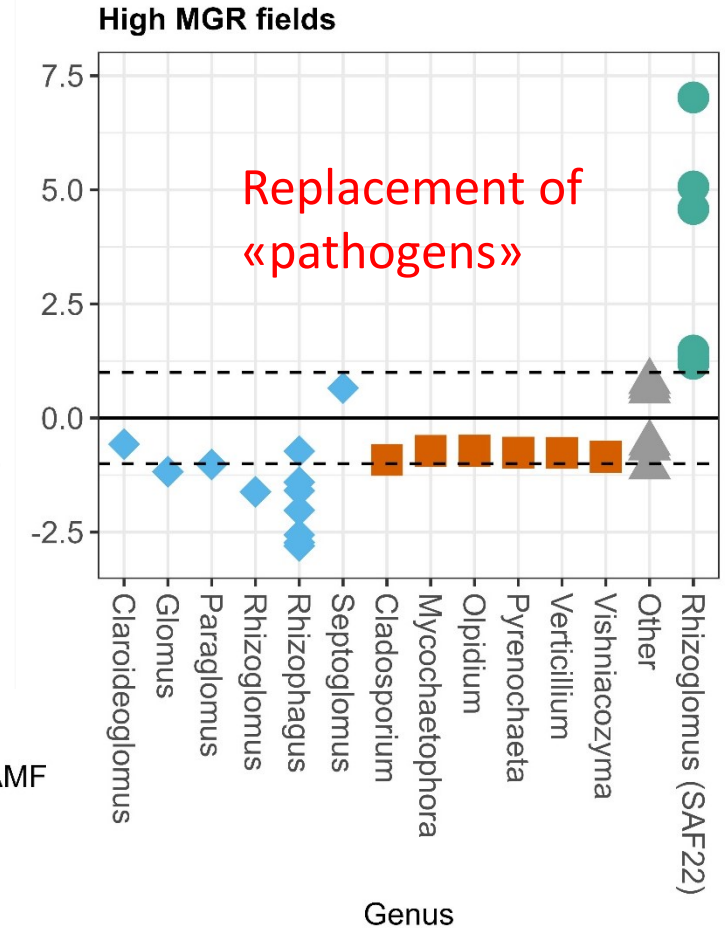




Abundance higher in **inoculated** samples

Abundance higher in **control** samples

Guild
- Inoculated AMF
- Native AMF
- Other
- Pathogen



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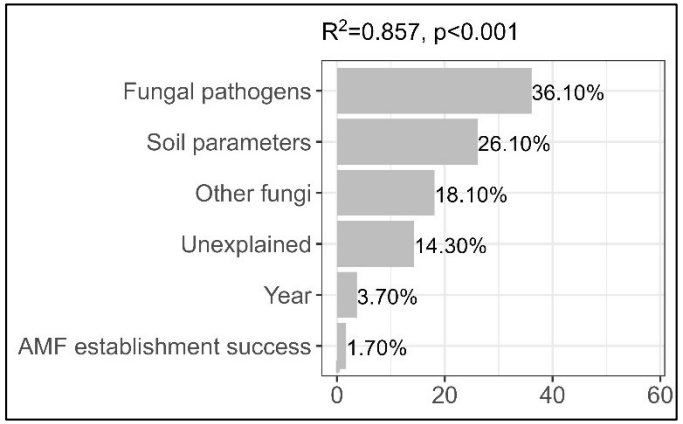
Conclusions

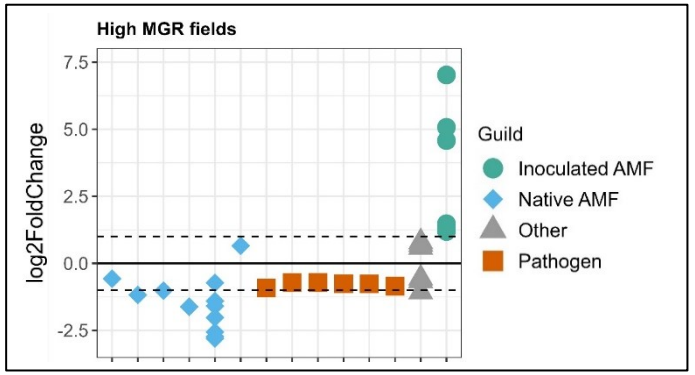
- **Predictions work!**

- **Soil fungal microbiome** more important than soil physico-chemical parameters in predicting maize growth response to AMF inoculation

- Abundance of **pathogenic fungi** best predicted (33%) AMF inoculation success

- **Root microbiome data confirms** findings of MGR prediction model





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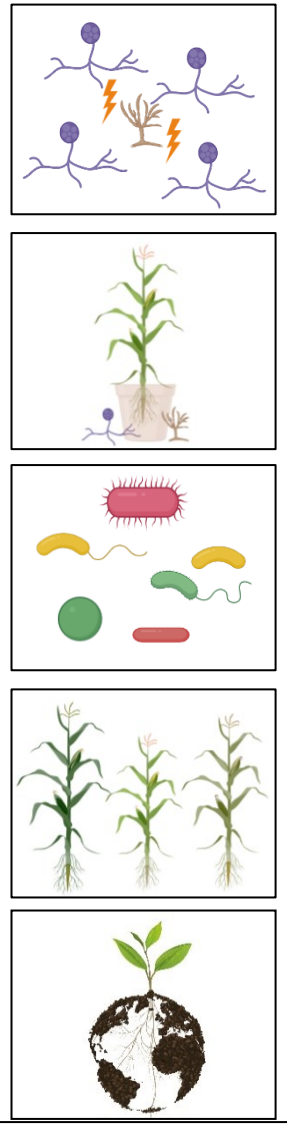
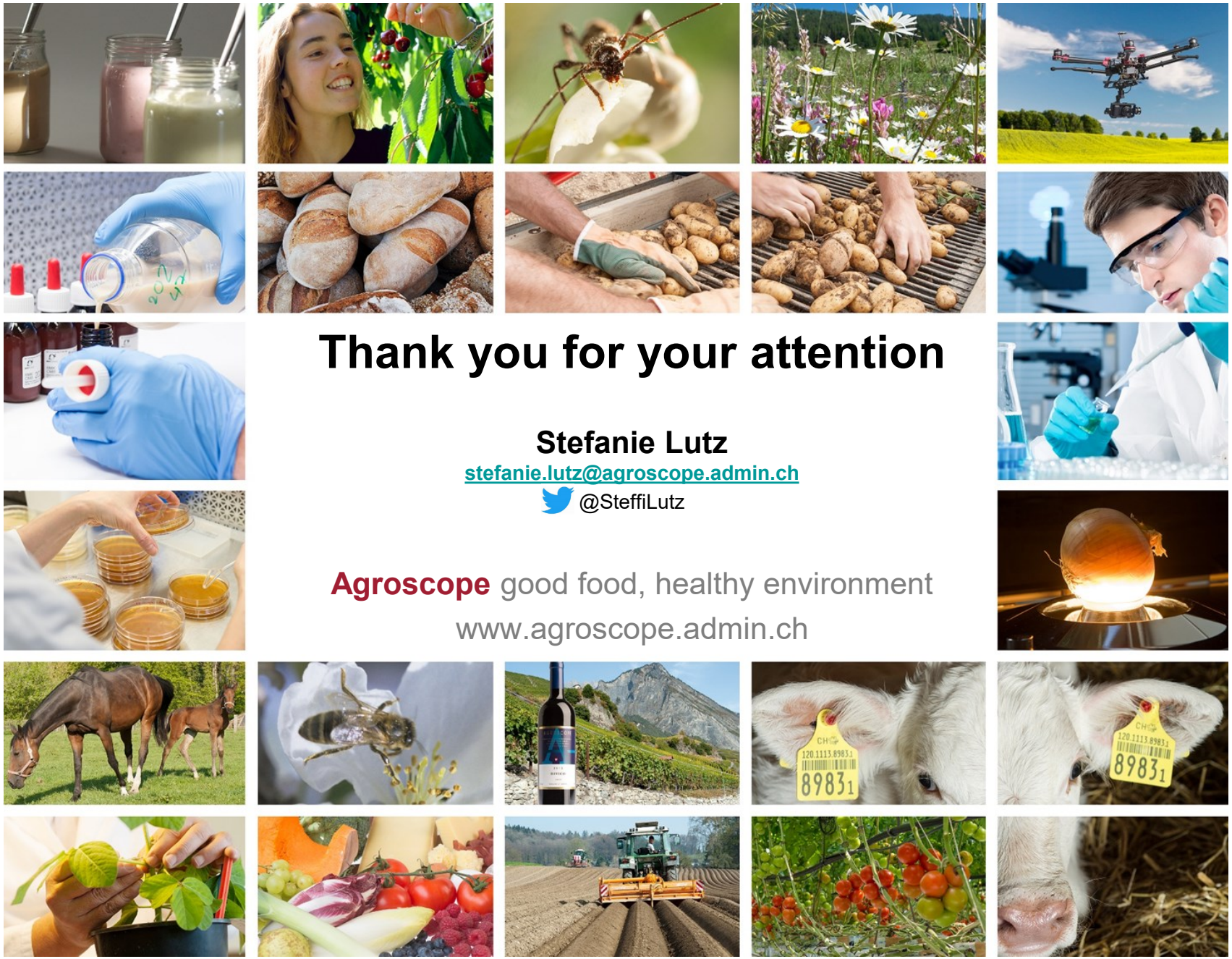
Outlook

- **Working hypothesis**: AMF can contribute to pathobiome management and act as “life insurance”

  → Inclusion of more field trials to verify hypothesis
- **Experimental evidence**: Testing AMF biocontrol potential in the greenhouse using closely related and common maize pathogens and the underlying mechanisms (transcriptomics, metabolomics)
- **Improvement of model**: Inclusion of bacterial microbiome predictors (Klaus Schlaeppi, Loïc Thurre, Jan Waelchli)
- **Extend the scope**: Using this blueprint to investigate the context-dependencies of other maize (crop) genotypes
- **Continuous improvement** of predictability of AMF inoculations to increase the profitability of microbiome engineering as a tool for sustainable agricultural management



Biorender.com



Thank you for your attention

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