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Microbial products – failure in field?

Example of mycorrhizal fungi

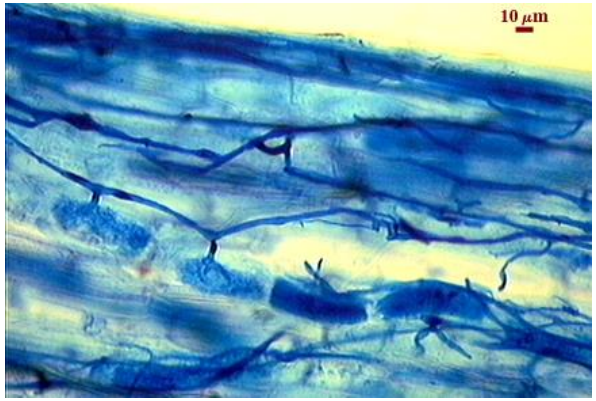
Christel Baum

Soil Biology, University of Rostock

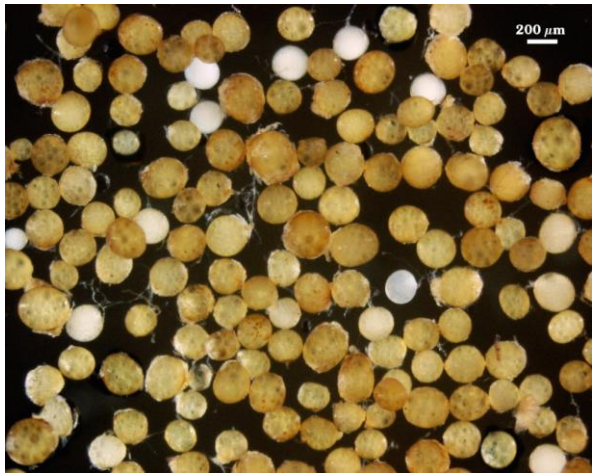
The problem

Author: C. Felgentreu

Arbuscular mycorrhiza formation



Arbuscular mycorrhiza
(fine root of *Zea mays*)



Spores of AMF (∅ 180-320 µm)

- mutualistic symbiosis of the majority of crop plants
- fungal partners: obligate symbionts, belonging to the phylum Glomeromycota

Most common fungal genera:

- *Acaulospora*
- *Diversispora*
- *Scutellospora*
- *Glomus*
- *Funneliformis*
- *Rhizoglomus*

(http://fungi.invam.wvu.edu)

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Mycorrhizal host plants in arable use

Botanic family	Crop name	Species
Fabaceae	Soya bean	*Glycine max* (L.) Merr.
	Red clover	*Trifolium pratense* L.
	Faba bean	*Vicia faba* L.
Linaceae	Flax	*Linum usitatissimum* L.
Poaceae	Oat	*Avena sativa* L.
	Millet	*Pennisetum glaucum* (L.) R.Br.
	Rye	*Secale cereale* L.
	Barley	*Hordeum vulgare* L.
	Wheat	*Triticum durum* Desf.
	Corn	*Zea mays* L.
Solanaceae	Potato	*Solanum tuberosum* L.

mod. Martın-Robles et al. (2017) New Phytologist, 218, Issue: 1, Pages: 322-334, DOI: (10.1111/nph.14962)

Benefits of mycorrhiza formation

Plant nutrition:

- Improved supply of P, N, Zn and water

Plant protection:

- Increased stress tolerance
- Induced resistance against pathogens

Soil fertility:

- Increased aggregate stability
- Decreased erosion
- Improved vertical nutrient transfer from sub- to topsoil
- Labile nutrient storage

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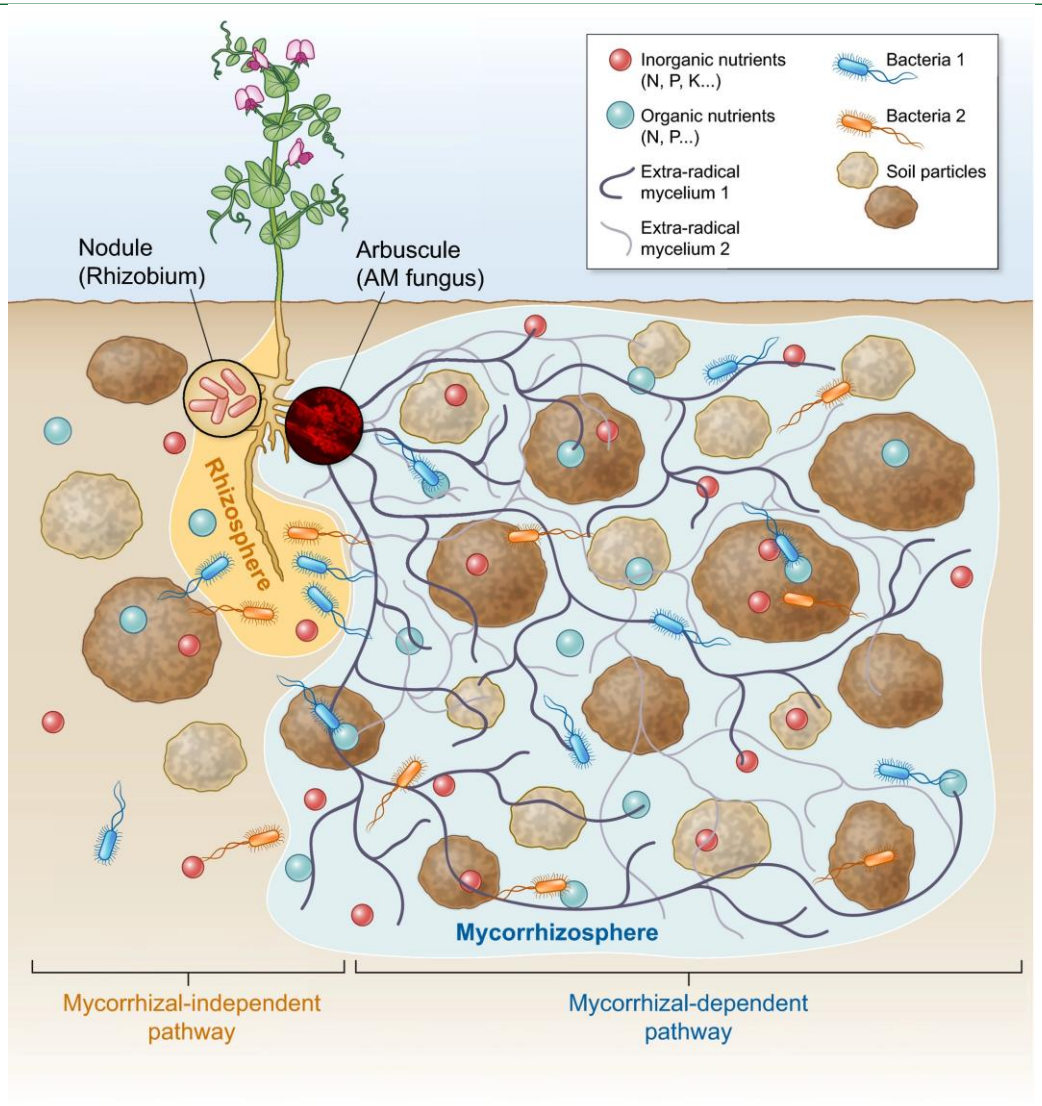
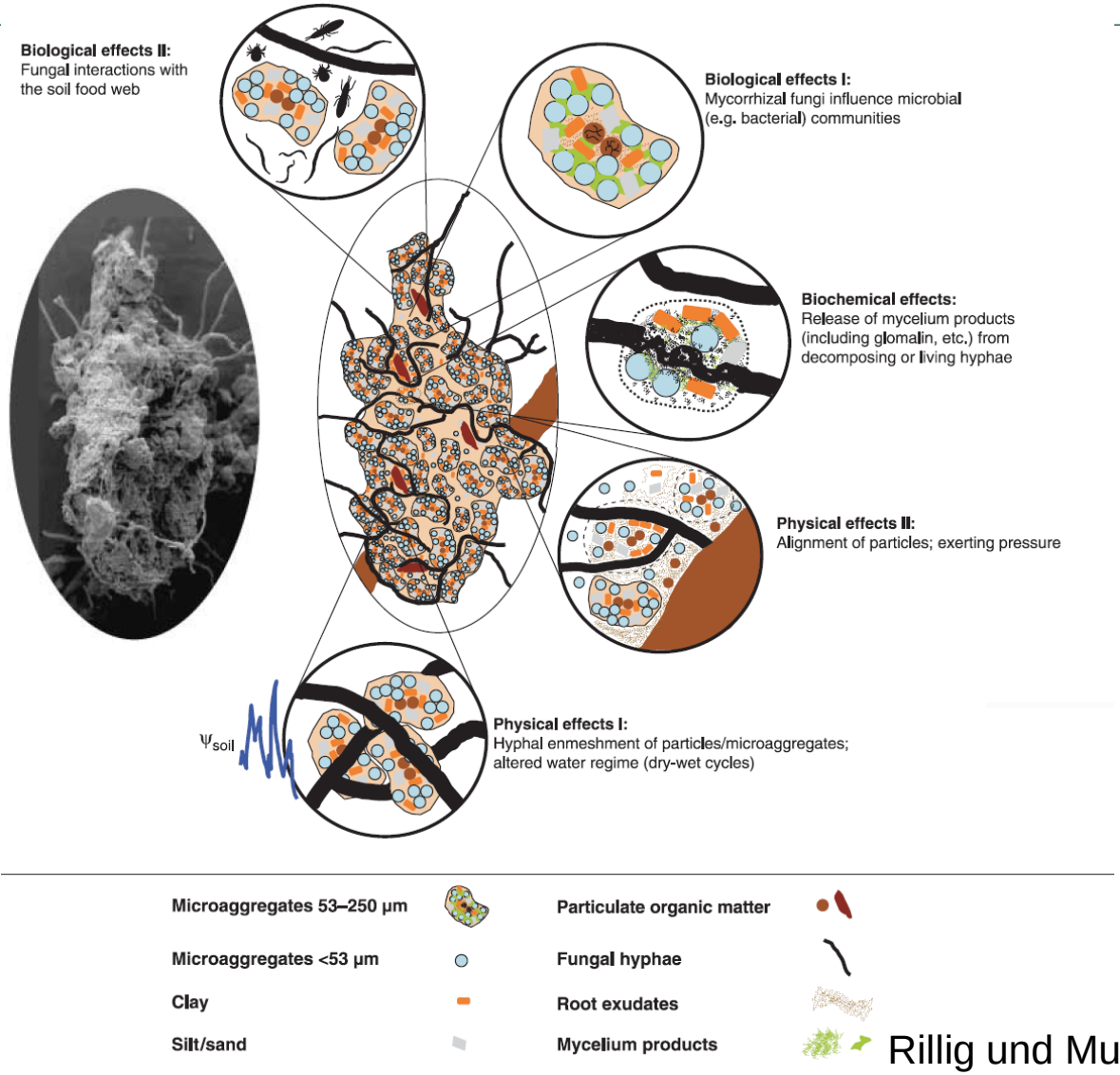
The mycorrhizosphere



increased catchement area for nutrients and water

Wipf et al. 2019 New Phytol.

Soil ecological significance



Rillig und Mummey (2006)

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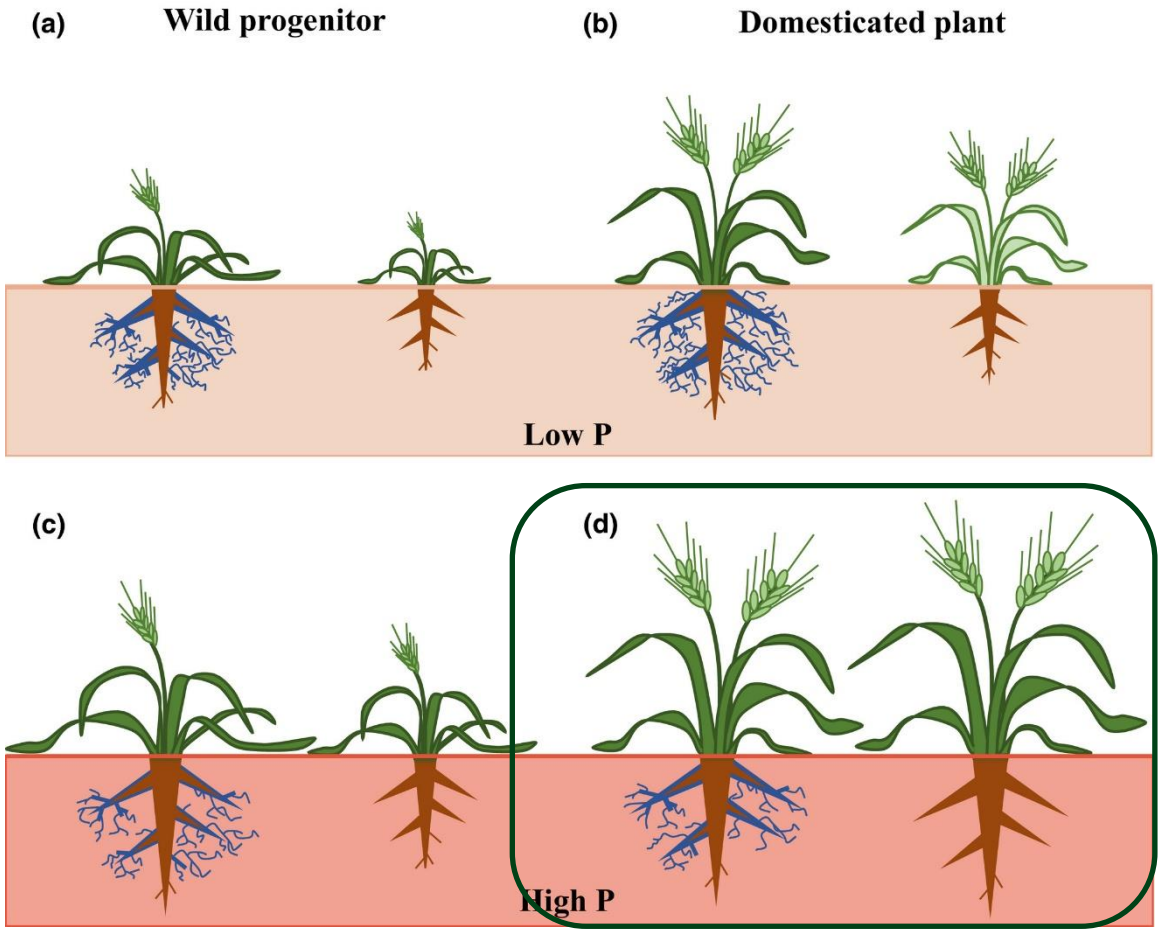
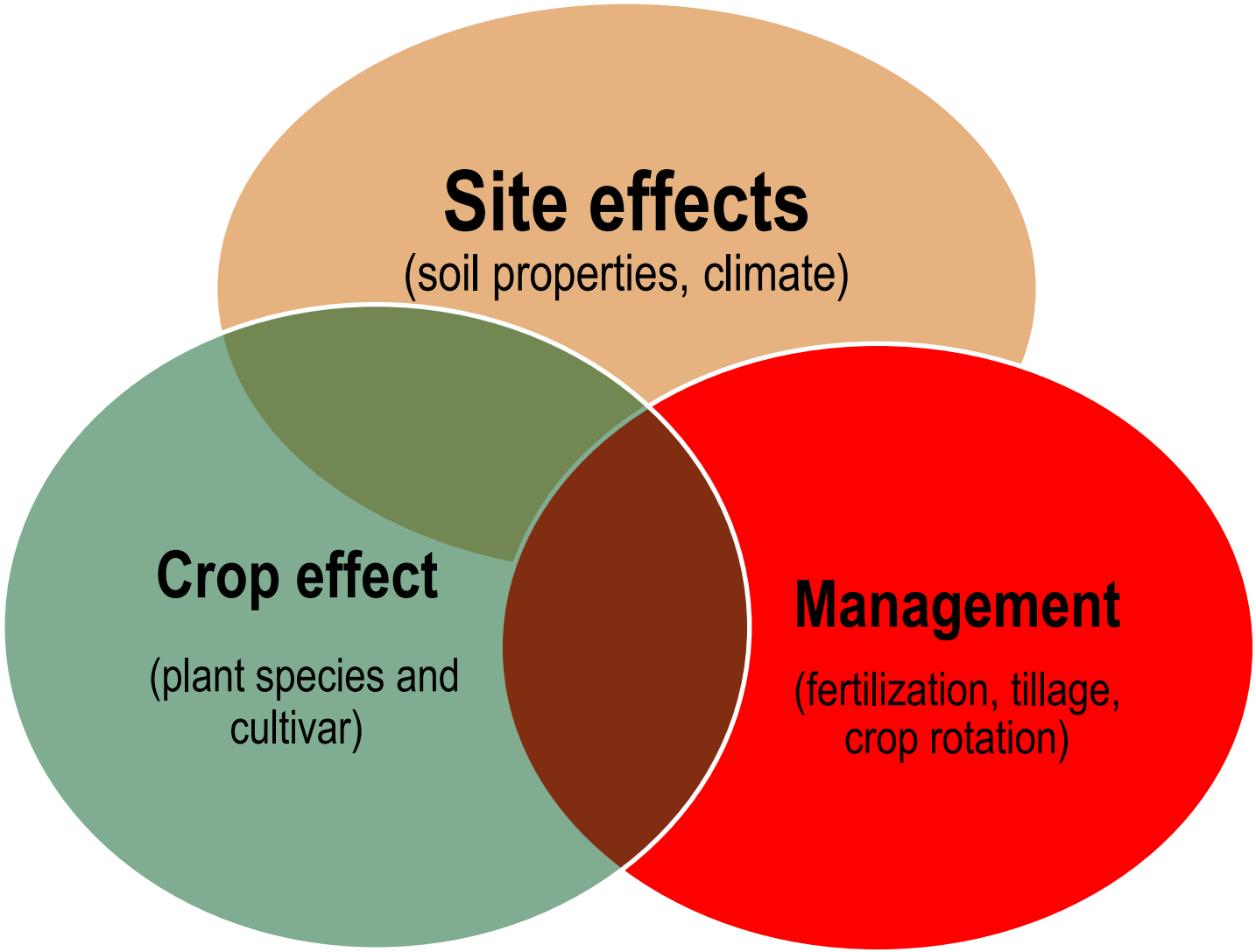
Impacts of domestication



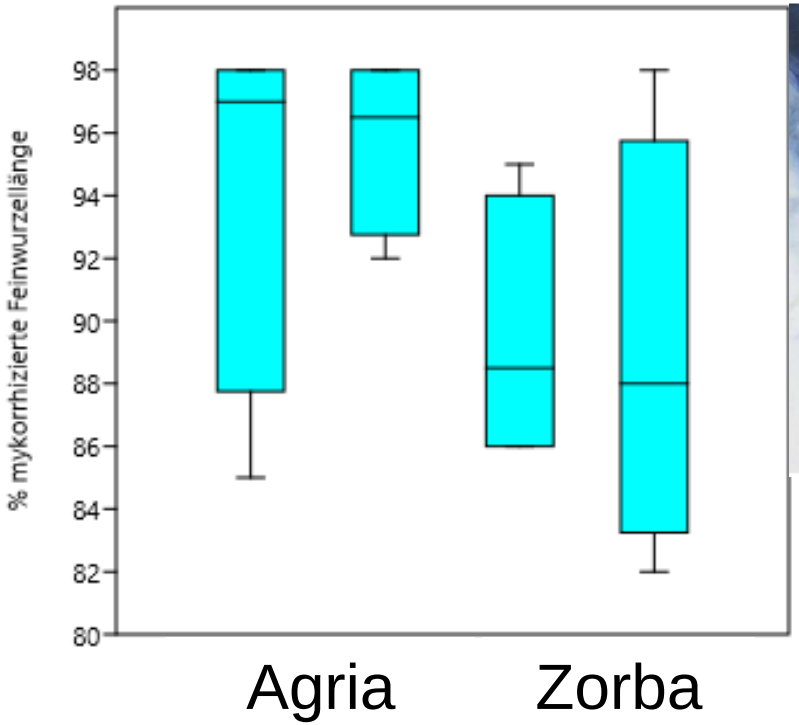
Martın-Robles et al. (2017) New Phytologist, DOI: 10.1111/nph.14962

Controls of mycorrhiza formation

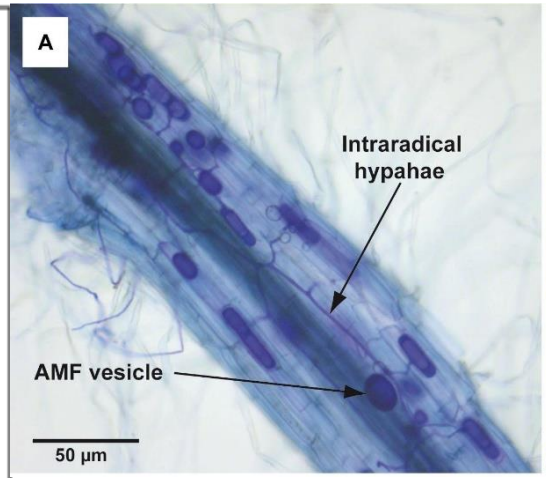


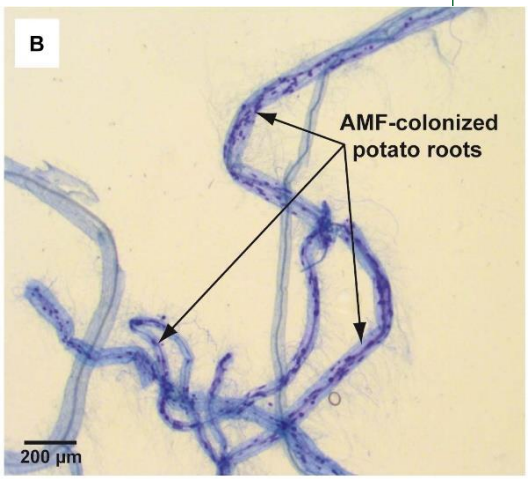
Effects of the genotype

Mycorrhiza formation (potato)



Baum (2023)

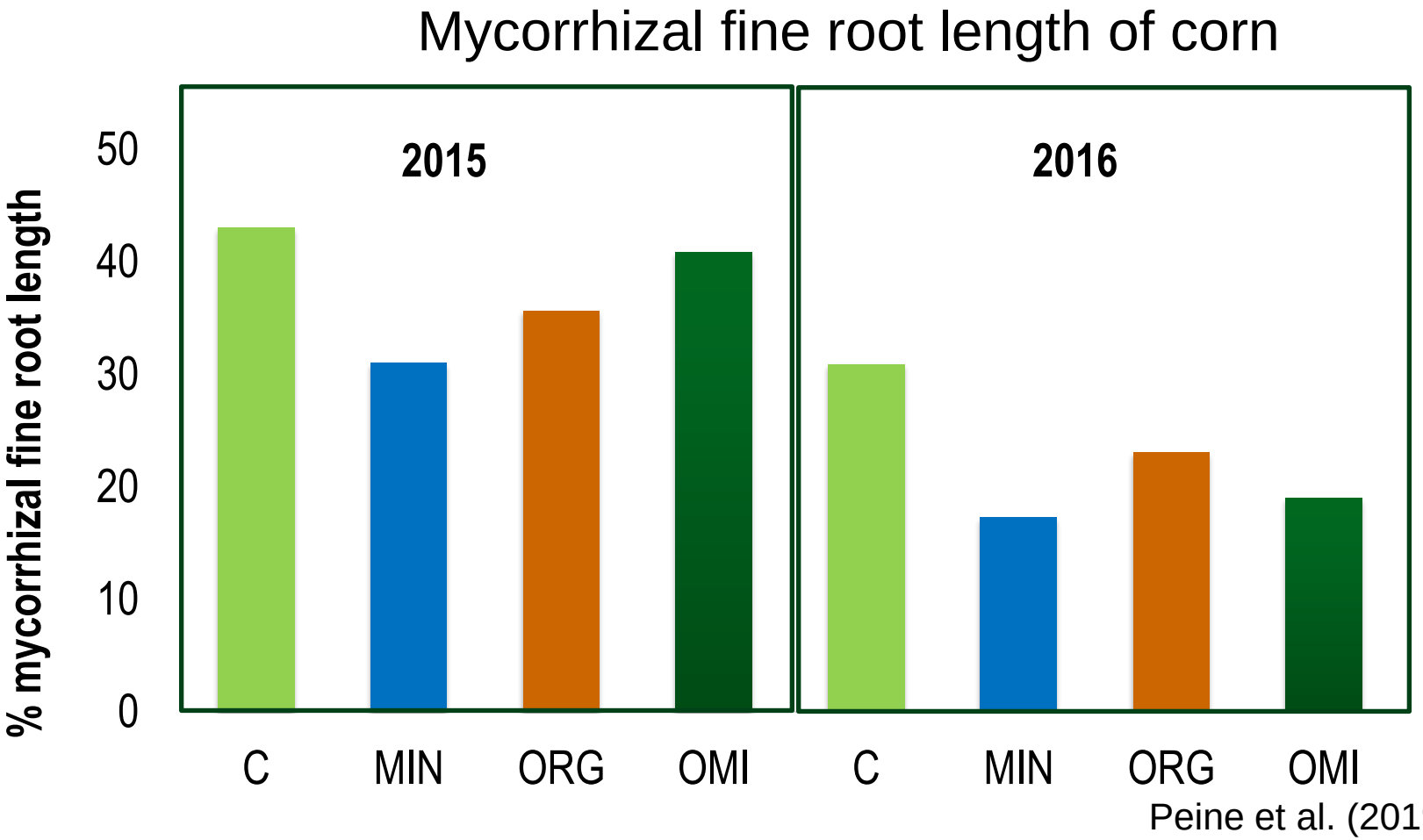




Deja-Sikora et al. (2020)

Significant impacts of the cultivar on mycorrhiza formation

Effects of P fertilization



Peine et al. (2019)

Treatments: C no P fertilization, MIN + TSP, ORG + compost, OMI + TSP and compost

Effects of fertilization

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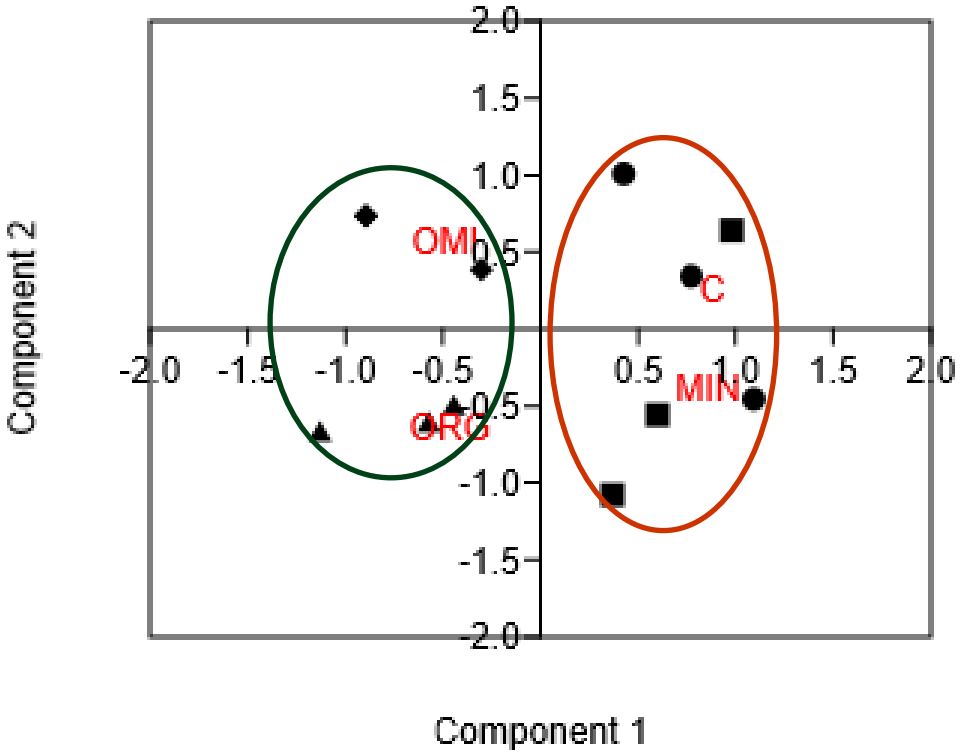

PCA of the genetic fingerprints of AMF under corn at the test site Rostock

Treatments: C no P fertilization, MIN + TSP, ORG + compost, OMI + TSP and compost

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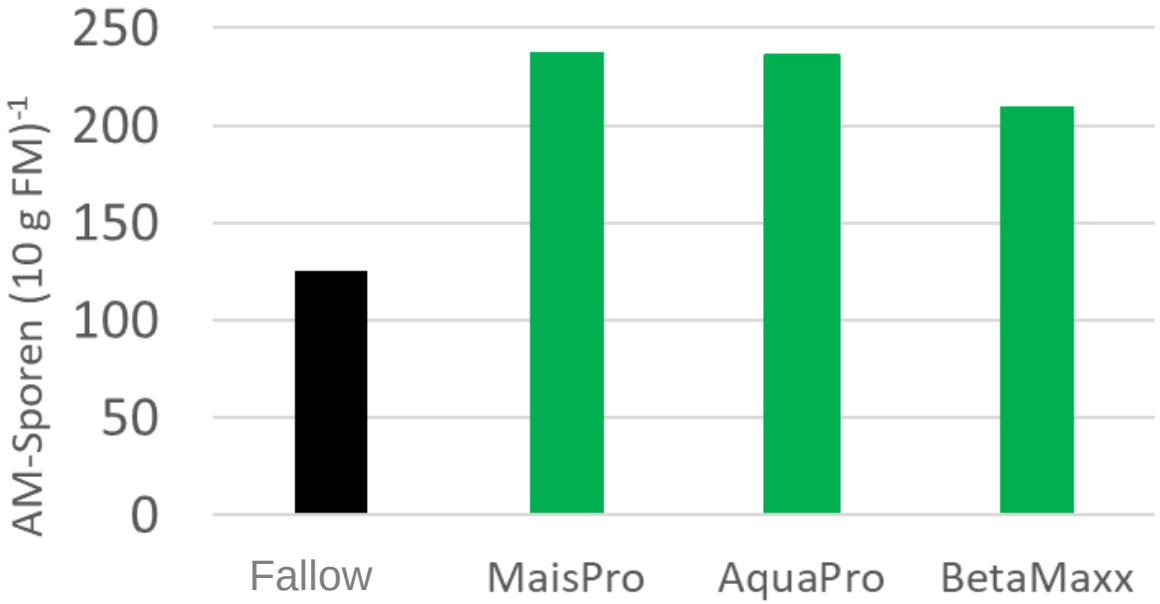
Effects of catch crops



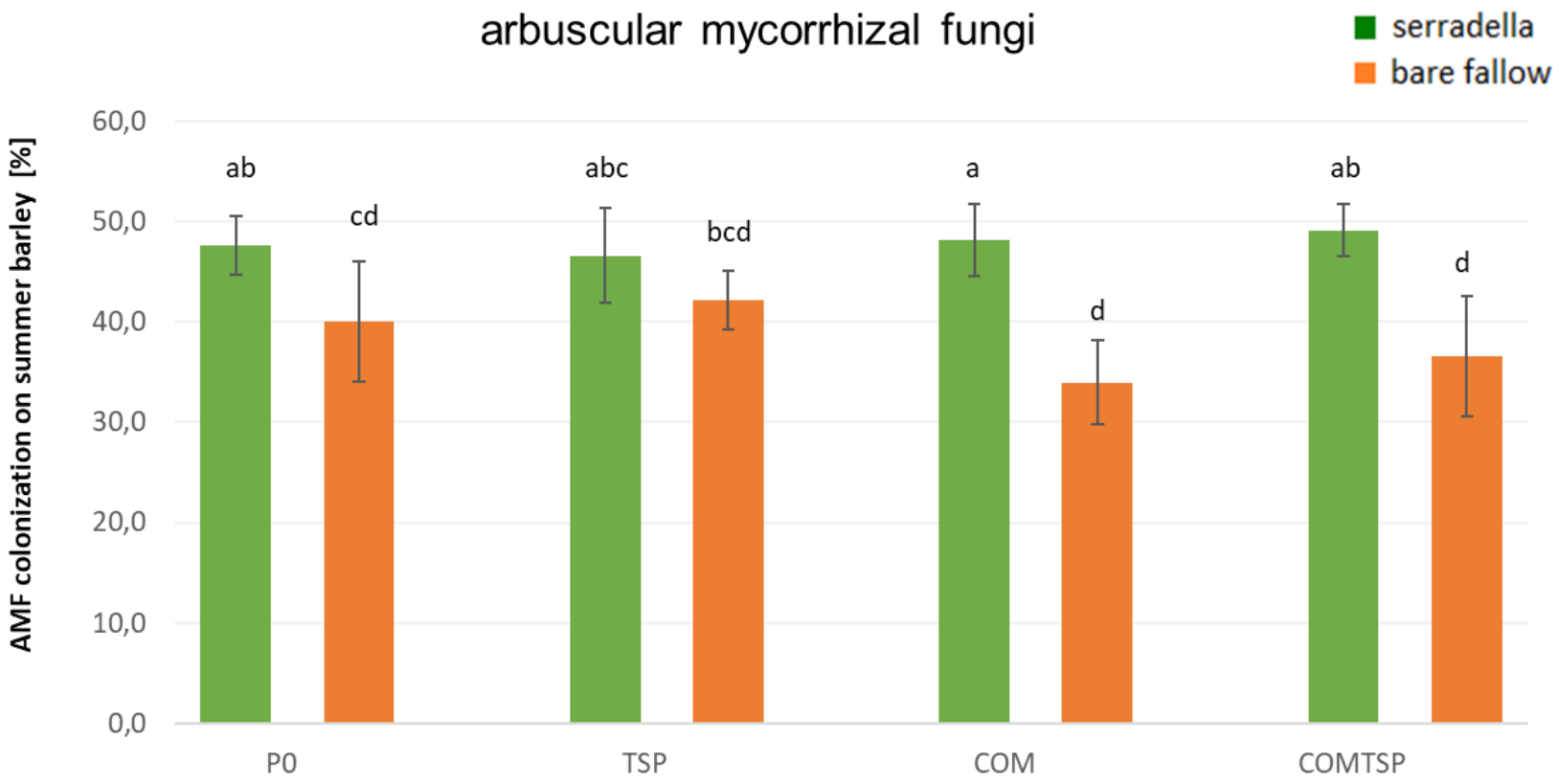
up to 100% higher spore density under catch crops compared to a bare fallow

Source: Kaminski, Felgentreu (DSV), 2018

Catch crop mixtures

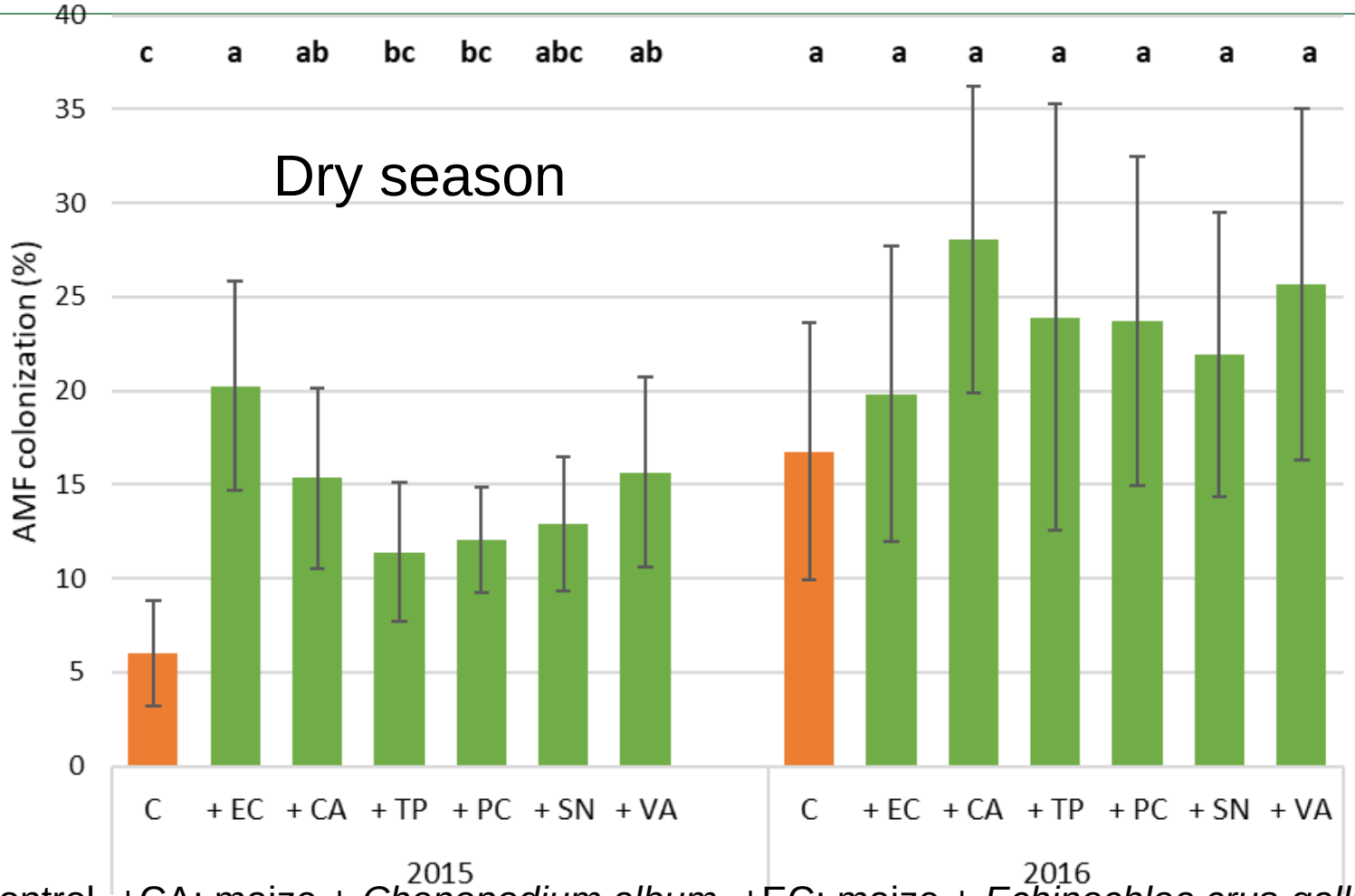
Treatment	Number of taxa	Main components in %	
Bare fallow	-	*no vegetation cover*	
MaisPro TR	14	*38% Pisum*	*13% Sorghum*
AquaPro	8	*37% Avena*	*14% Phacelia*
BetaMaxx	7	*25% Vicia*	*24% Pisum*

Effects of catch crops



up to 14% higher mycorrhizal colonization of summer barley after seradella cropping, Author: N. Vitow

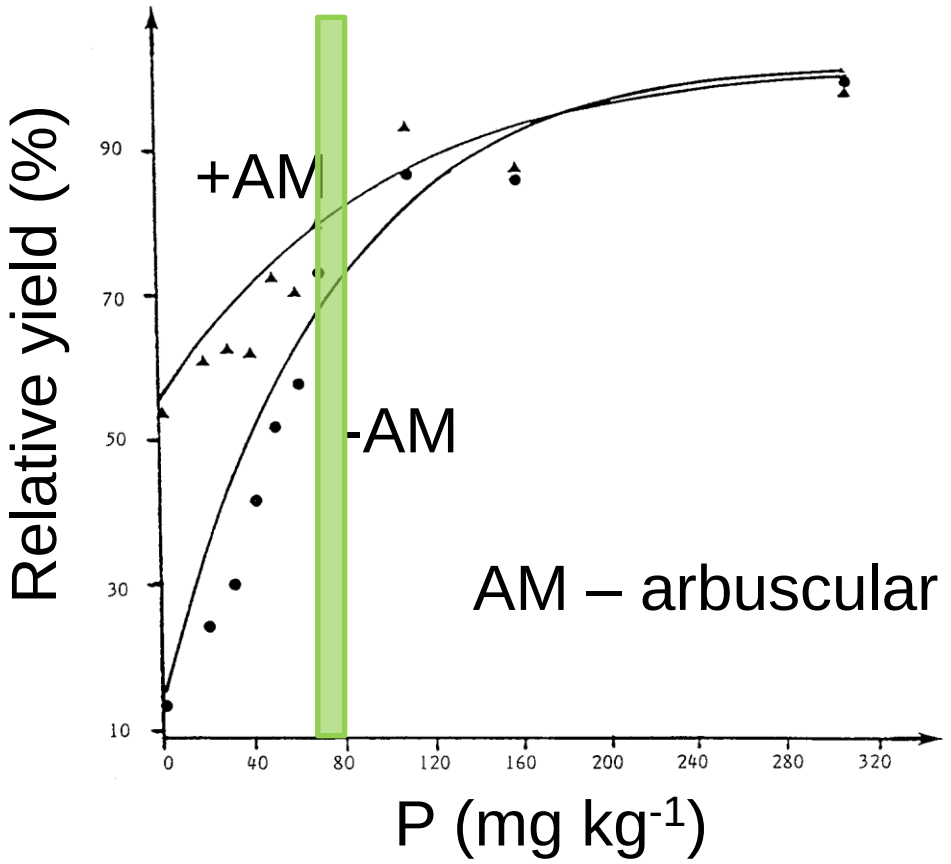
Effects of weeds



C: control, +CA: maize + *Chenopodium album*, +EC: maize + *Echinochloa crus-galli*, +TP: maize + *Tripleurospermum perforatum*, + SN: maize + *Solanum nigrum*, + PC: maize + *Polygonum convolvulus*, + VA: maize + *Viola arvensis*) Author: A. Zacher

Limitations of mycorrhizal use

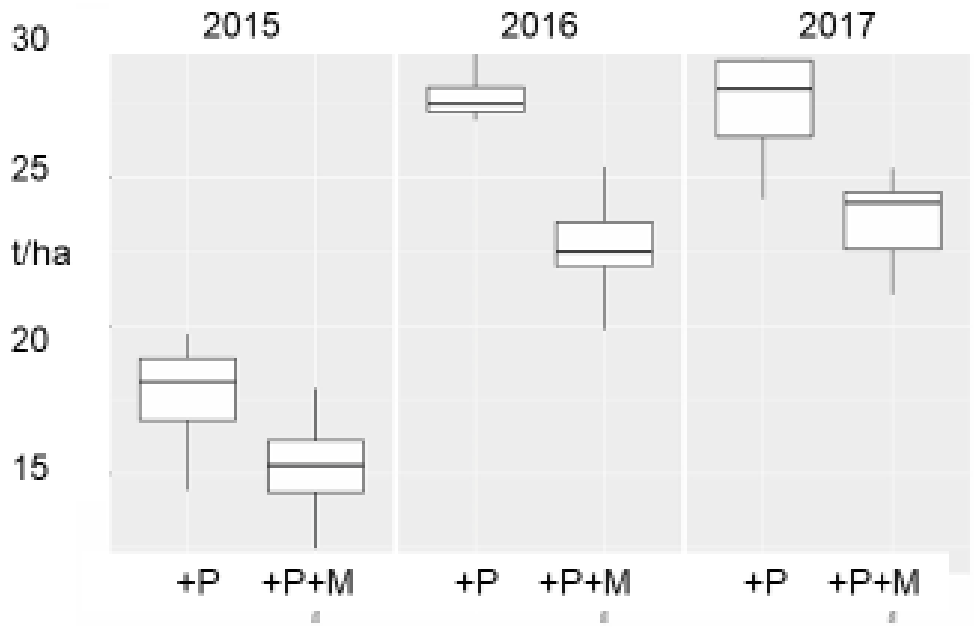
Decreased use of mycorrhiza in increased soil P concentration



Example : soybean
(mod. Plechette & Morel, 1996)

AM – arbuscular mycorrhizal colonization

Application of mycorrhizal inoculum in arable soils



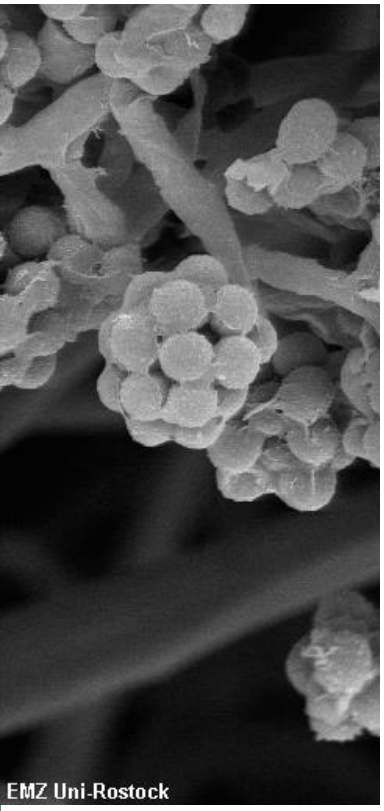
Example: corn in a field experiment

+P
P-fertilization
+M mycorrhiza inoculation

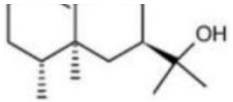
Thielicke, M.; Ahlborn, J.; Eichler-Löbermann, B.; Eulenstein, F. On the Negative Impact of Mycorrhiza Application on Maize Plants (*Zea mays*) Amended with Mineral and Organic Fertilizer. Microorganisms 2023, 11, 1663. https://doi.org/10.3390/microorganisms11071663

5

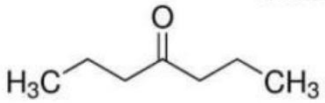
Outlook on other plant growth promoting microorganisms: *Trichoderma*



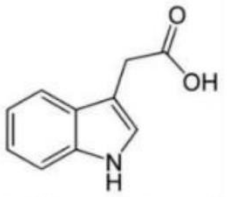
A



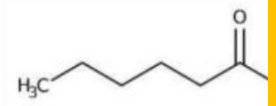
Valerianol



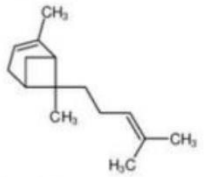
4-Heptanone



Indol-3-acetic acid



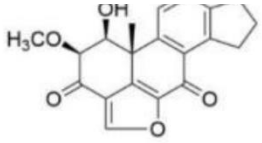
3-Octanone



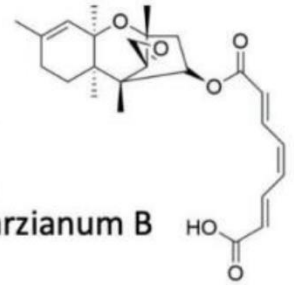
Alpha-Bergamotene

Plant growth-promoting metabolites

B

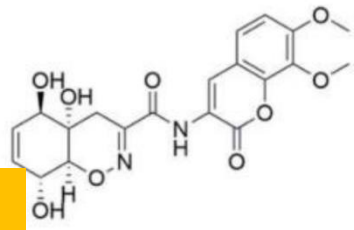


Viridine

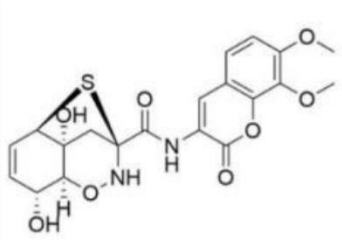


Harzianum B

biocontrol



Trichodermamide A



Aspergilazine A

Guzmán-Guzmán P, et al. *Plants*. 2023; 12(3):432. https://doi.org/10.3390/plants12030432

Conclusion and outlook

Reasons for failure in the field:

1. Site effects: weather conditions, soil conditions
2. Management effects: fertilization / tillage / variety

Outlook:

Biologicals with direct use of active substances instead of living organisms (e.g. enzymes, phytohormones)

Thank you!

BONARES

Project: InnoSoilPhos (No. 031A558)

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung