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The Plant II Microbiome
Giza Pyramids Vicinity, Egypt - 2024

Agronomic measures to support microbial activities and functions in soil with focus on plant P nutrition

Bettina Eichler Löbermann, Christel Baum, Lena Geist, Gebeyanesh Zerssa

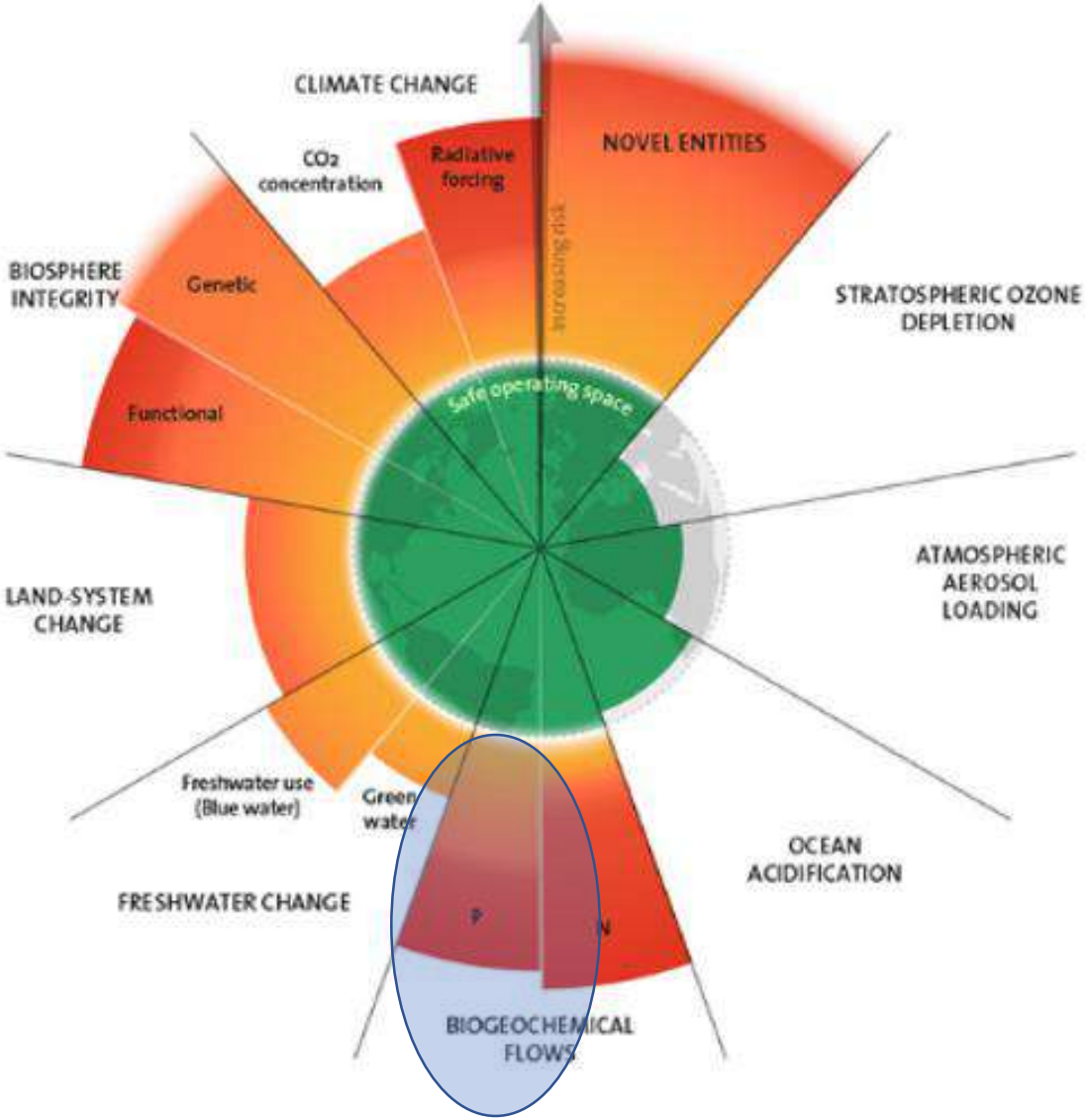
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Planetary boundaries

…describe limits to the impacts of human activities on the Earth system.

Beyond these limits, the environment may not be able to self-regulate anymore



Sustainable P management!

Under consideration of microbioal P turnover

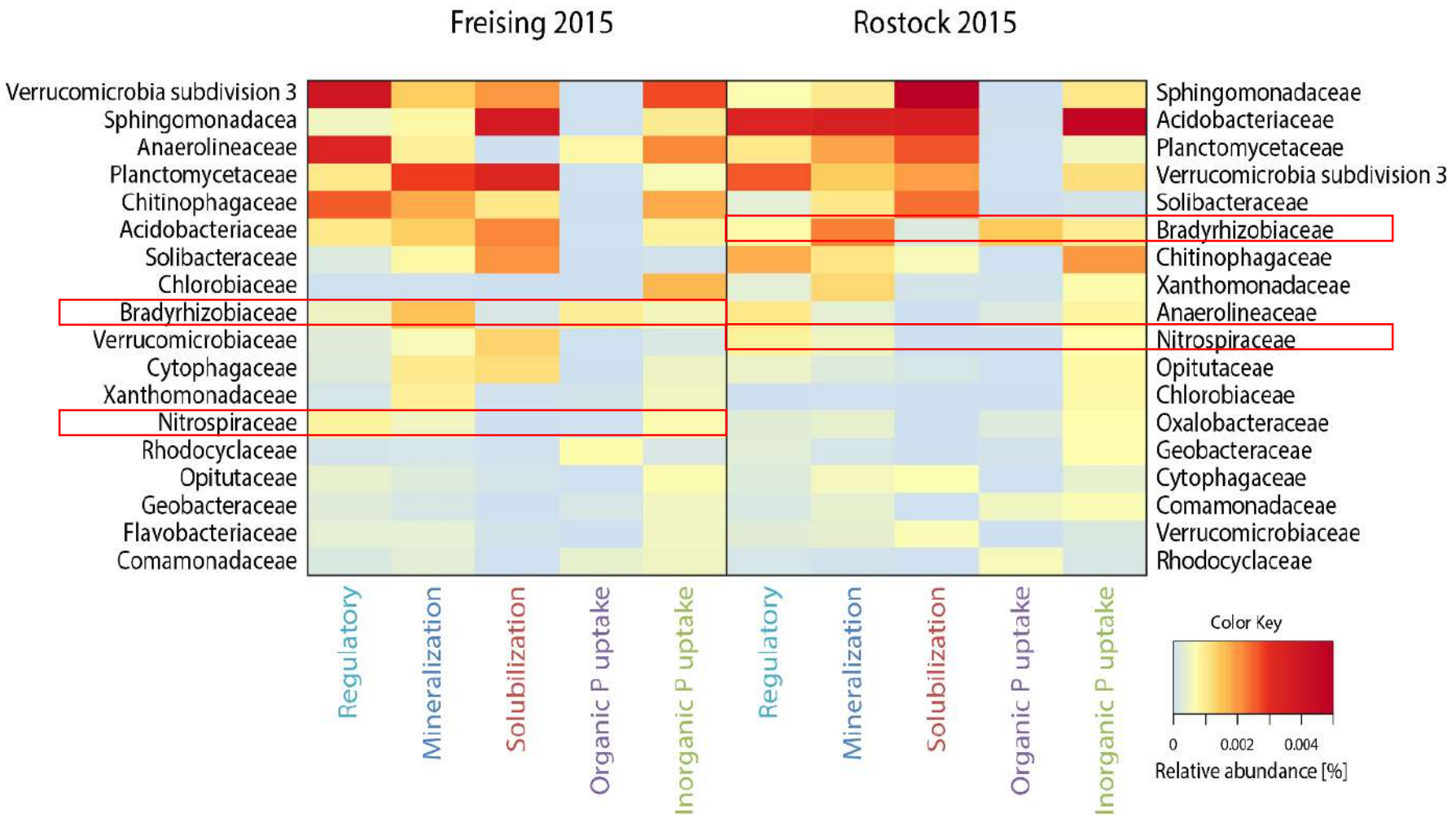
Stockholm Resilience Centre | Stockholm University

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Microbial families involved in the P turnover (examples)

Rhizosphere microbiome of maize at two test sites –



Mean relative abundances of genes involved in P turnover harboured by different families in Freising and Rostock, by means of a heatmap.

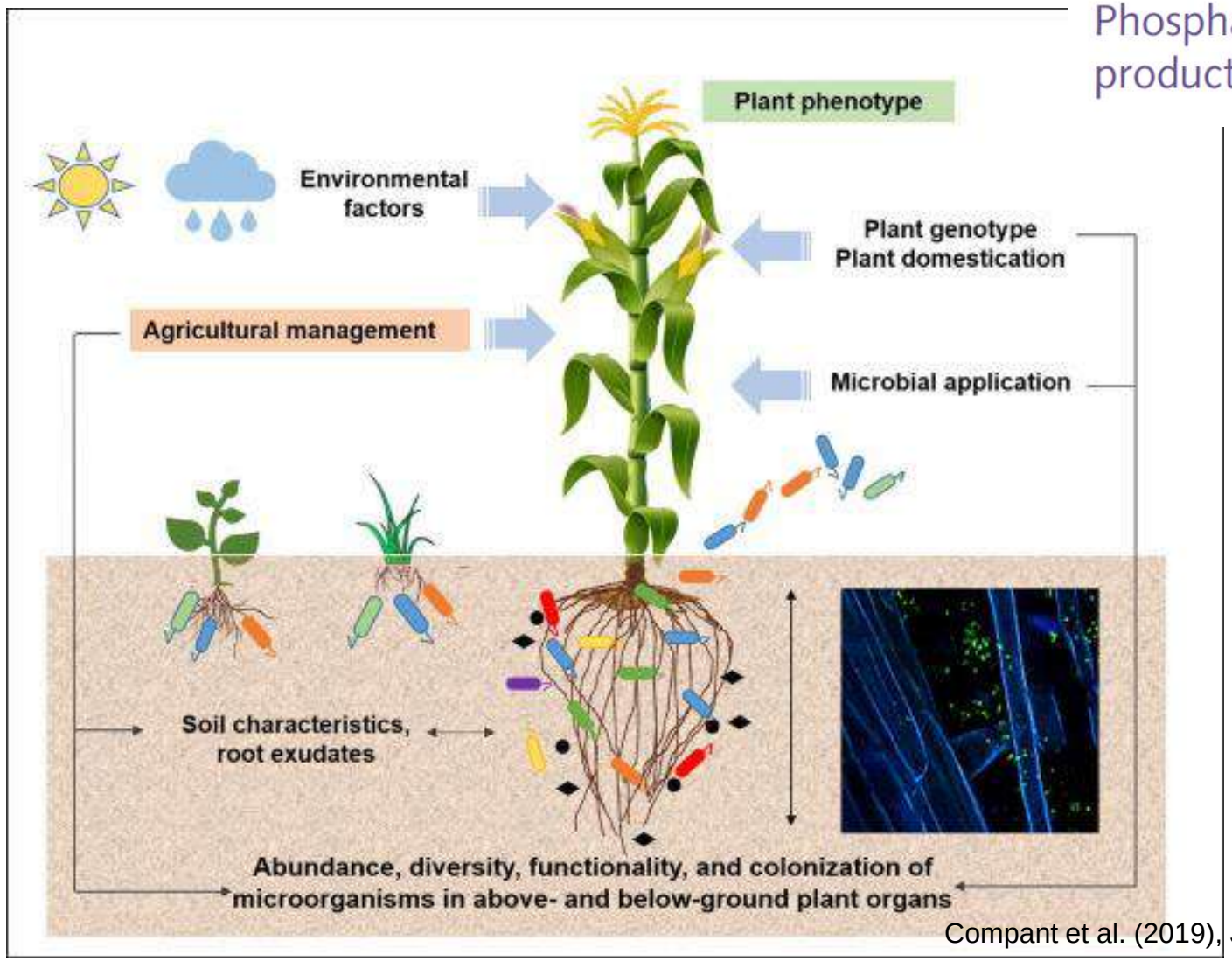
Grafe et al. 2018

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New Phytologist

Microbial application vs agronomic management



Research review

Phosphate-solubilising microorganisms for improved crop productivity: a critical assessment

Raymond et al. 2020 New Phytol.

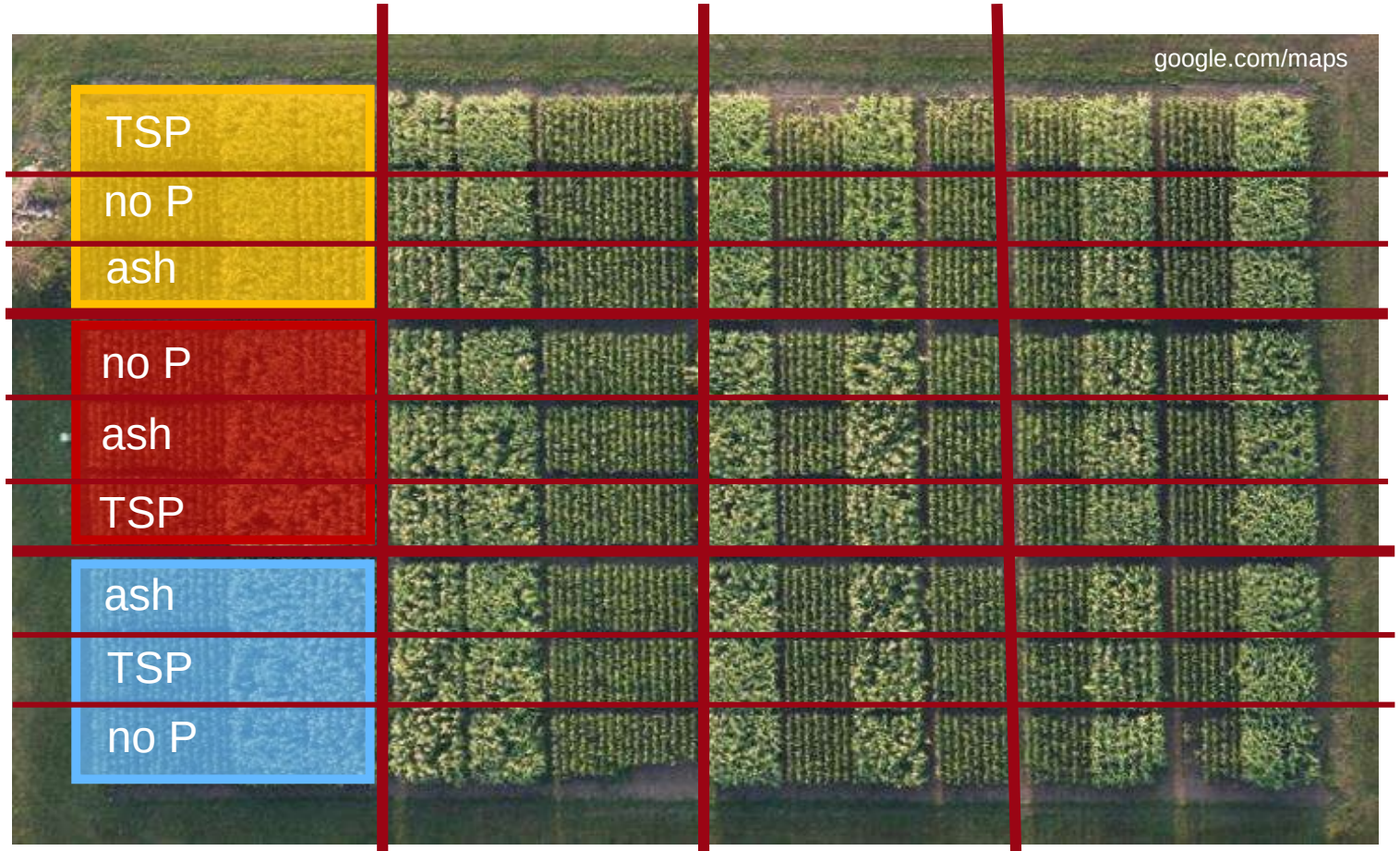
Studies under controlled and field conditions

Characteristics:

- Yield effects
- Activities of enzymes
- Root architecture and mycorrhiza formation
- Microbial nutrient turnover
- Microbial diversity
- ….

Compant et al. (2019), J. Adv. Res.

Long-term field experiment



ash: biomass ash TSP: triple superphosphate

Established since 1998

Split-plot design

whole-plot factor: organic fertiliser
Compost
Manure
No P

split-plot factor: inorganic fertiliser

9 treatments
4 replications

Application of microorganisms in dependence of organic matter management – PGPR in the soil-plant system…

better performance of applied PGPR along with organic amendments
(e. g. Peix et al. 2001, Ramírez & Kloepper 2010, Mirshekari et al. 2011)



?

more effective when applied to poor soils
(e. g. De Freitas & Germida 1992, Egamberdiyeva & Höflich 2003, Shaharoona et al. 2008)

modified Krey 2013

Maize yield - Yield increase only in 2007

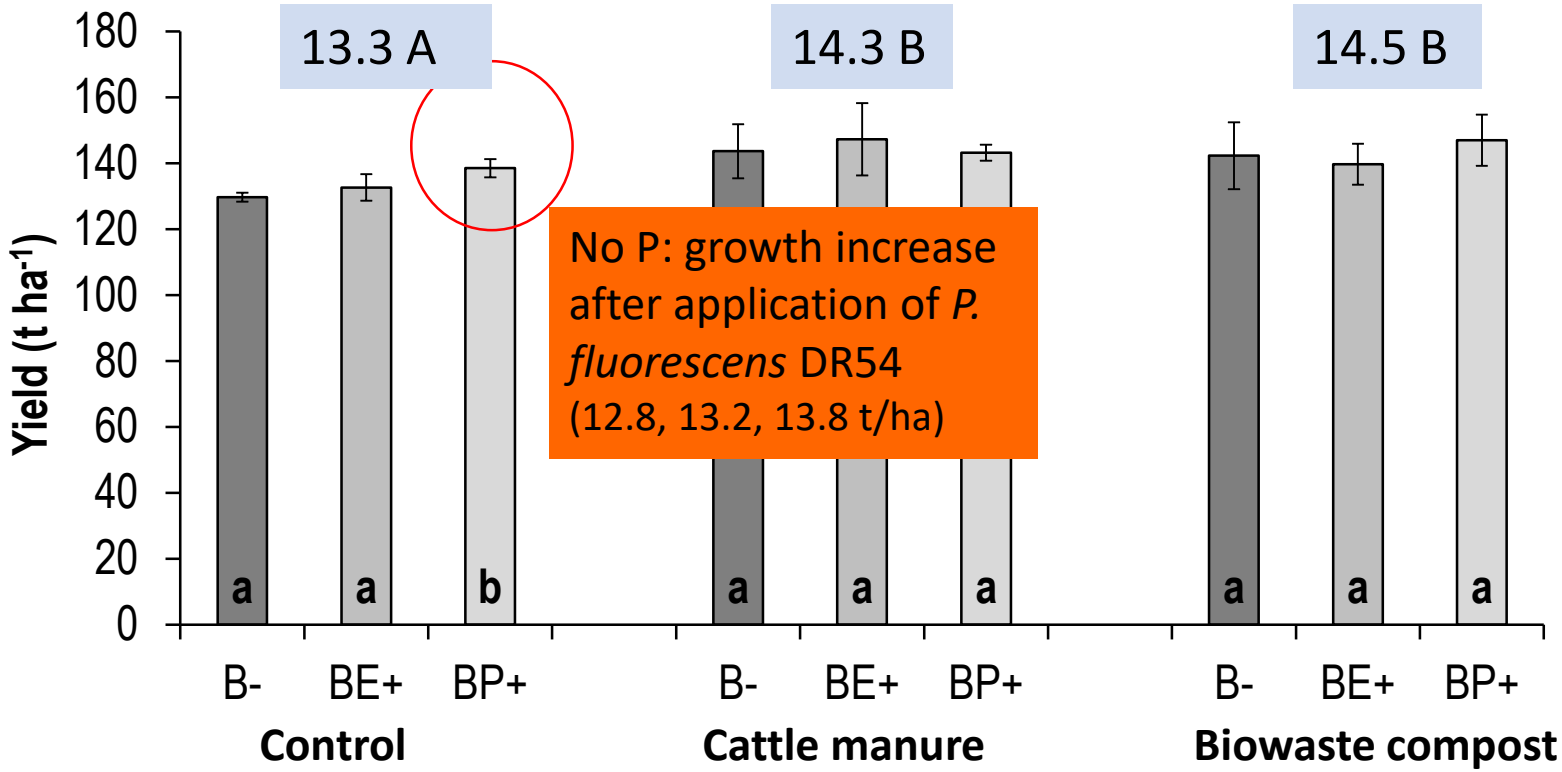


Fig.: Field experiment, B-, non-inoculated control, BE+, ***Enterobacter radicincitans*** D5/23^{T}, BP+, ***Pseudomonas fluorescens*** DR54 (Duncan-Test, $p \leq 0.05$, $n = 4$, means ± SD)

Arbuscular mycorrhizal colonization maize

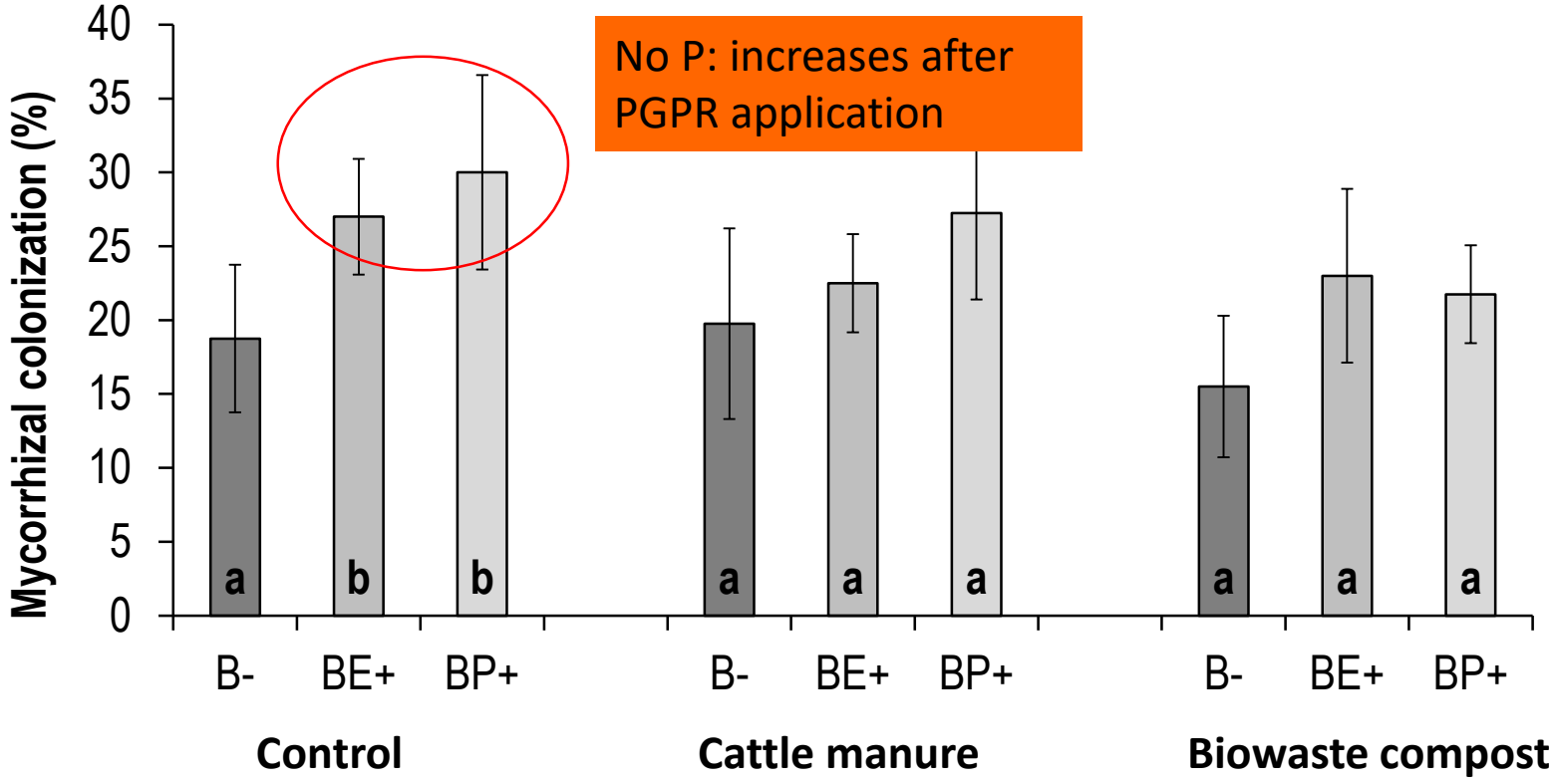


Fig.: Field experiment, B-, non-inoculated control, BE+, ***Enterobacter radicincitans*** D5/23^T, BP+, ***Pseudomonas fluorescens*** DR54 (Duncan-Test, $p \leq 0.05$, $n = 4$, means ± SD)

Krey et al. 2013 – Europ. J. Soil Biol.

Alkaline phosphatase activities in the rhizosphere of maize

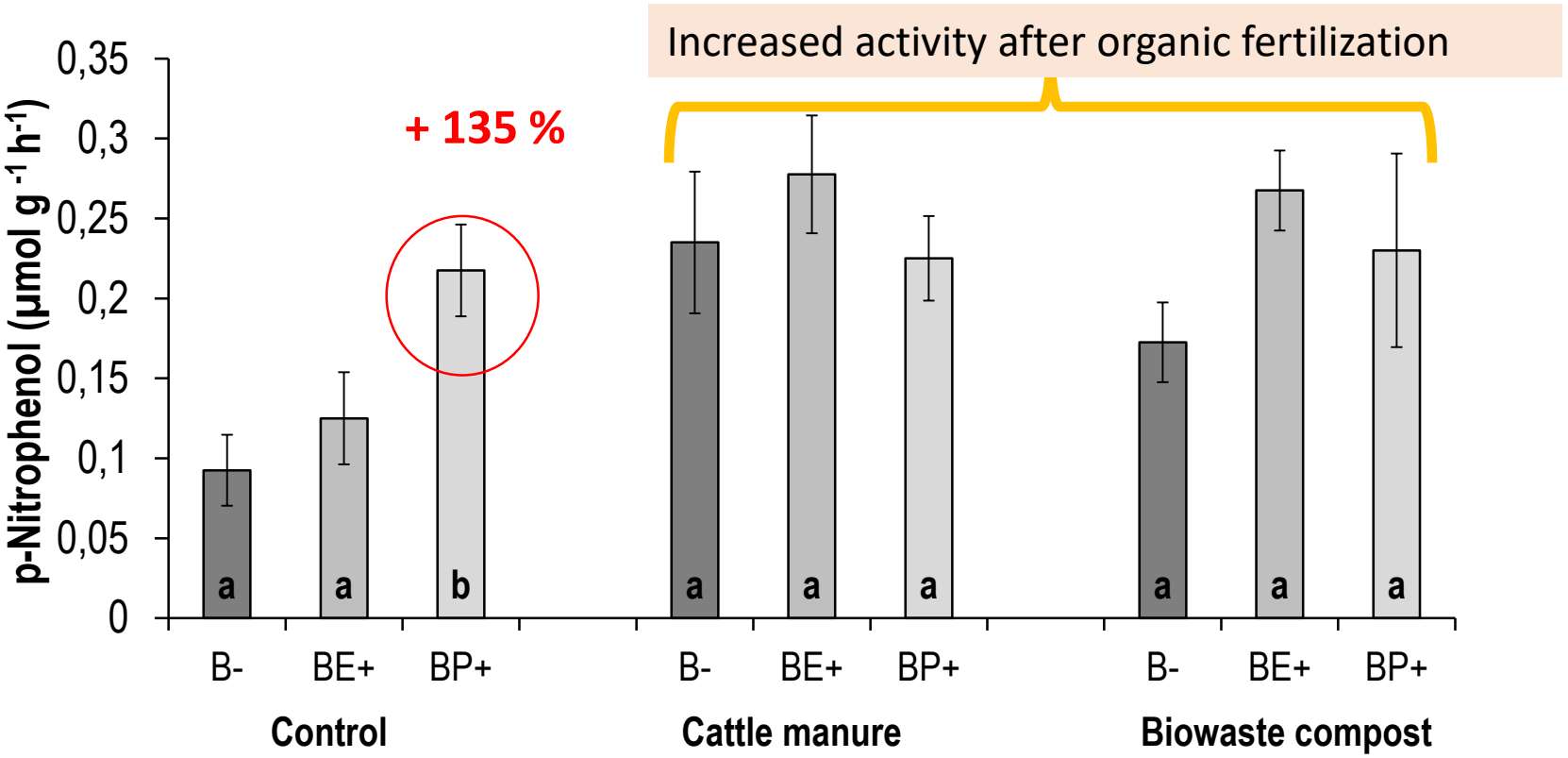


Fig: Semi-field B-, non-inoculated control, BE+, ***Enterobacter radicincitans*** D5/23^T, BP+, ***Pseudomonas fluorescens*** DR54 (Duncan-Test, $p \leq 0.05$, $n = 4$, means ± SD)

Krey et al. 2013 – Europ. J. Soil Biol.

Soil P pools

Fertilizer	PGPR	pH	P_w (mg kg^{-1})	P_{dl} (mg kg^{-1})	P_{ox} (mmol kg^{-1})	PSC (mmol kg^{-1})	DPS %	SOM%
Control, no P	B–	5.53 a	8.88 a	31.5 a	11.8 a	28.2 a	41.8 a	2.28 a
	BE+	5.57 a	8.83 a	33.8 a	11.2 a	26.9 a	42.0 a	2.24 a
	BP+	5.56 a	10.7 b	34.4 a	12.0 a	28.1 a	42.7 a	2.33 a
Mean **Control**		5.55 A	9.46 A	33.2 A	11.7 A	27.2 A	42.1 A	2.28 A
Cattle manure	B–	5.76 a	11.8 a	40.0 a	12.7 a	27.7 a	45.6 a	2.41 a
	BE+	5.75 a	12.0 a	43.3 a	12.4 a	28.1 a	44.1 a	2.47 a
	BP+	5.76 a	13.1 a	42.3 a	13.0 a	27.4 a	47.5 a	2.51 a
Mean **Manure**		5.75 B	12.3 B	41.8 B	12.7 B	27.7 A	45.8 B	2.46 B
Biowaste compost	B–	5.79 a	13.2 a	49.8 ab	12.8 a	26.5 a	48.6 a	2.72 a
	BE+	5.78 a	14.1 a	46.6 a	13.5 a	28.2 a	47.9 a	2.63 a
	BP+	5.76 a	15.5 b	56.0 b	13.5 a	25.6 a	52.9 a	2.65 a
Mean **Compost**		5.78 B	14.3 C	50.6 C	13.3 B	26.8 A	49.8 C	2.67 C
TSP	B–	5.57 a	11.7 a	40.1 a	12.9 a	27.3 a	47.6 a	2.33 a
	BE+	5.66 a	12.2 a	40.2 a	12.7 a	27.7 a	45.9 a	2.30 a
	BP+	5.65 a	13.7 b	43.5 a	12.8 a	26.3 a	48.8 a	2.41 a
Mean **TSP**		5.63 A	12.5 B	41.3 B	12.9 B	27.1 A	47.4 BC	2.34 A

Krey et al. 2013, Eur. J. Soil Biol

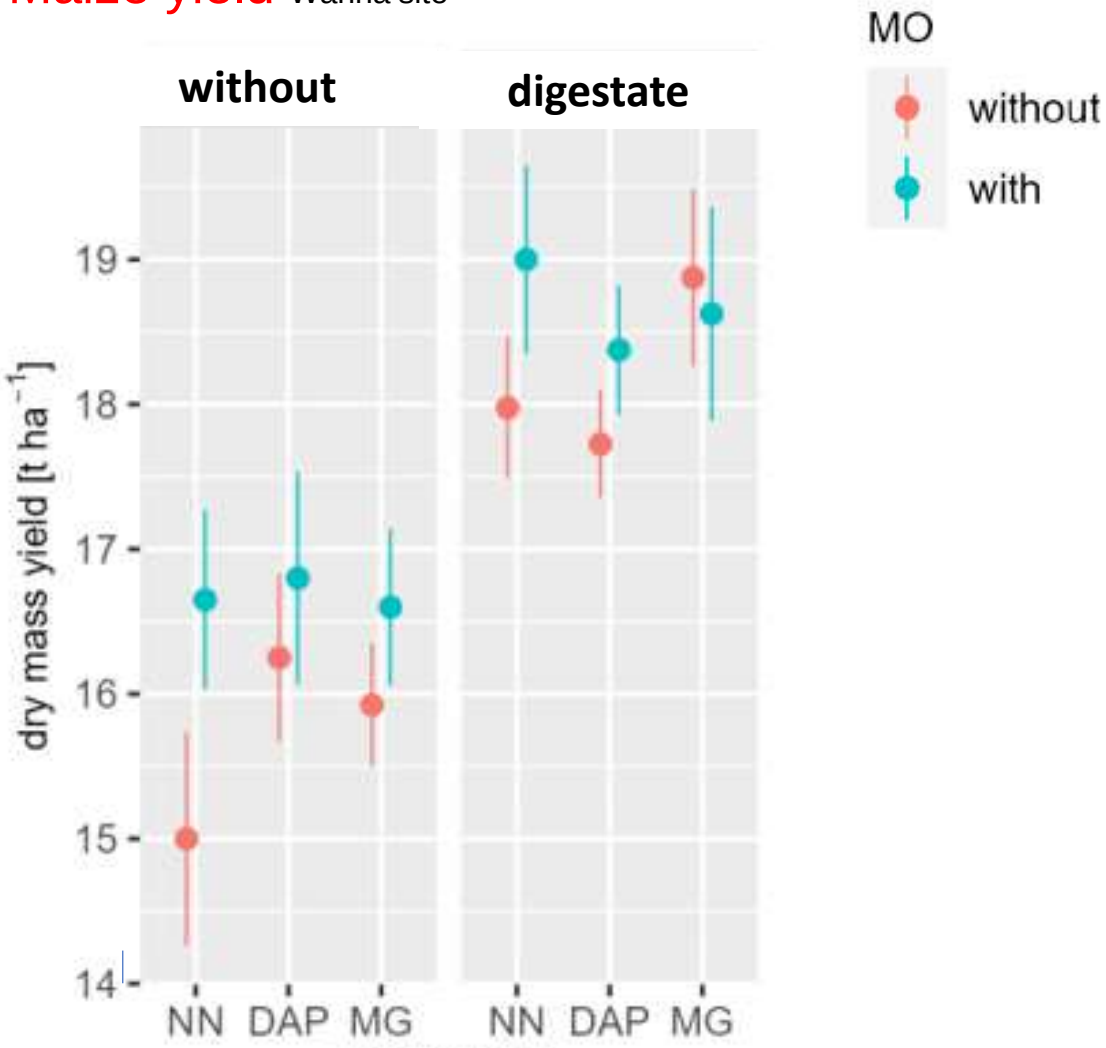
Microbial inoculants in dependence of digestate application – study on 4 sites in Lower Saxony (Germany)



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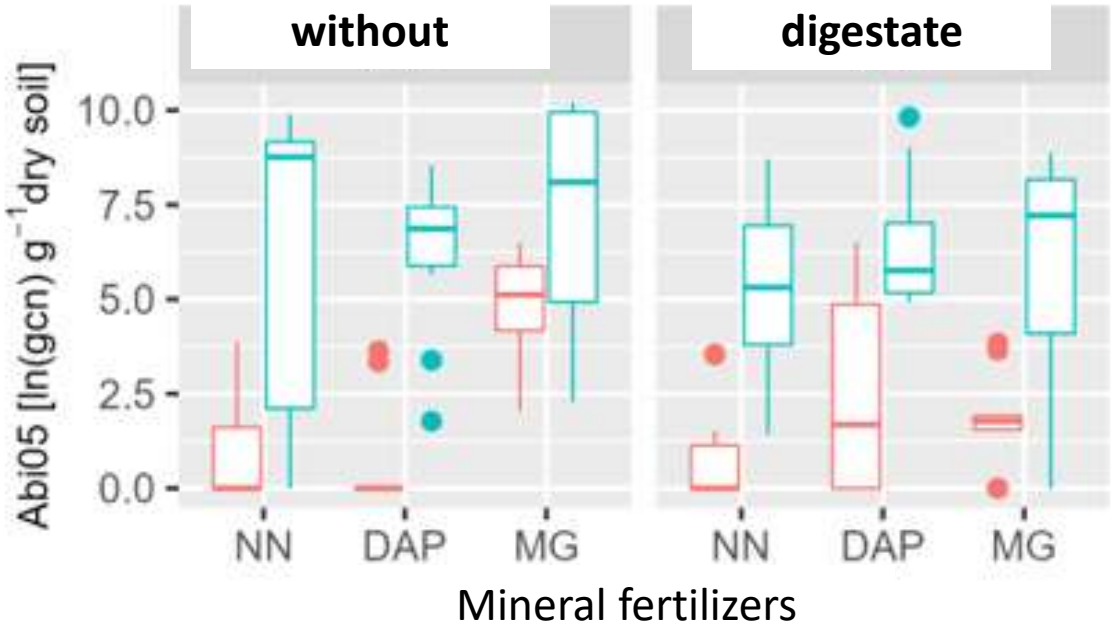
Maize yield Wanna site



Mineral fertilizers

Application of combined inoculum containing AMF *and B. atrophaeus*

Abundance of strain *B. atrophaeus* Abi05



Mineral fertilizers

natural logarithm of genome copy numbers

Geist et al. 2023

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Mixed Cropping and activities of soil enzymes





Maize + Phaseolus bean
Sorghum + Andean lupine

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Activities of enzymes involved in the P turnover as affected by organic fertilizers and mixed cropping

Factor	Level	AcP µg p-NP gTS^{-1}		AlP µg p-NP gTS^{-1}		DH µg TPF gTS^{-1}	
Organic	Without	130		30.0	a	39.3	a
	Manure	129		35.0	b	44.5	b
	Compost	131		40.3	c	46.0	b
Crop	Maize	125	a	32.2	a	40.7	b
	M + bean	134	b	33.2	a	49.5	d
	Sorghum	122	a	34.5	a	36.9	a
	S + lupin	138	c	40.8	b	46.0	c

Phosphatases
AcP – mainly plant controlled
AlP - mainly fertilizer controlled

DH - microbial activity

AcP = acid phosphatase, AlP = alkaline phosphatase, DH = dehydrogenase, p-np = p-nitrophenol, TPF = triphenylformazan
Different letters indicate different means between fertilizer treatments and crop species, (Duncan Test, $p \leq 0.05$)

Eichler-Löbermann et al. 2021, Field Crops Res

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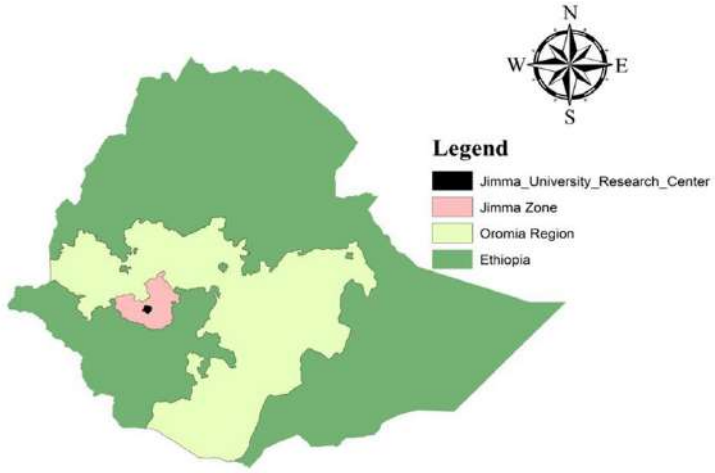
Focus on Africa…..

Review on smallholder Farming in Ethiopia - Adopting Climate-Smart Agriculture

Organic matter management identified as the most important measure



- Yield stability/ Increased productivity
- Reduction of erosion
- Carbon sequestration.
- Reduction of GHG emissions
- Soil fertility, water storage
- Soil microbial activity…….



In cooperation with Jimma University and Hawassa University, Ethiopia
Zerssa et al. 2021

Conclusion

Importance of microbial P turnover (mainly on soils with low P availability)

Native soil microbiome should be considered as a functional unit that is able to promote the mobilization of P

Effect of microbial applications strongly dependent on site characteristics

Organic matter management and divers cropping system for efficient utilization of nutrients

People involved in the study

- Thomas Krey
- Yue Hu
- Lena Geist
- Frank Eulenstein
- Mathias Thielicke
- Richard Thiem
- Stefanie Busch
- Theresa Zicker
- Gebeyanesh Zerssa
- Dong-Gill Kim