Microbial communities' contribution to soil and plant health

Silke Ruppel,

Leibniz Institute of Vegetable and Ornamental Crops

SPONSORED BY THE

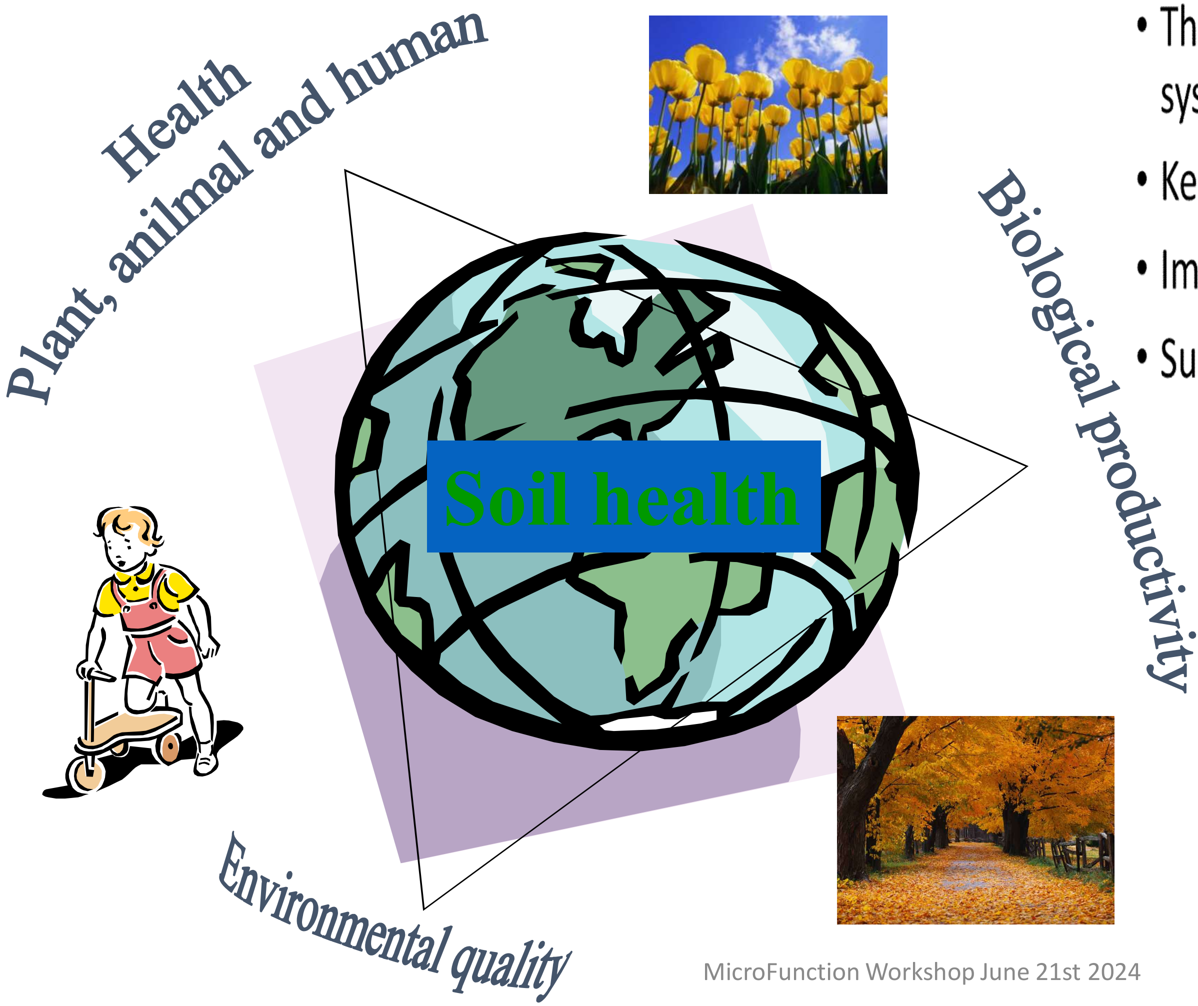
Federal Ministry of Education and Research

IGZ objective:

- to carry out basic and applied research supporting the sustainable production of vegetable and ornamental plants and the rational use of natural resources.

Reasearch Group
Beneficial Plant Microbe Interactions

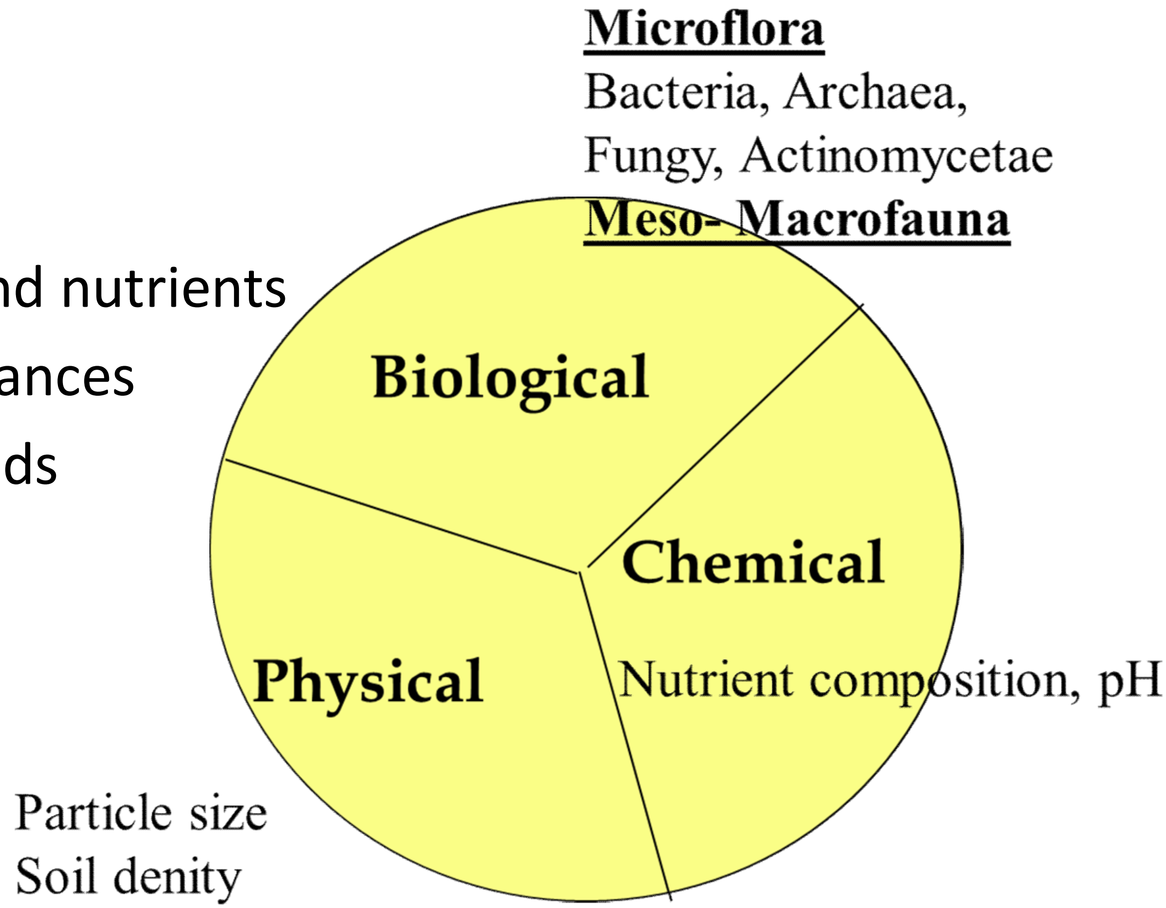
Main areas which determine soil health



- The soil sustainability to function as a vital living system within ecosystems
- Keeping soil biological productivity
- Improving air and water quality
- Sustaining plant, animal and human health

Functions of a healthy soil

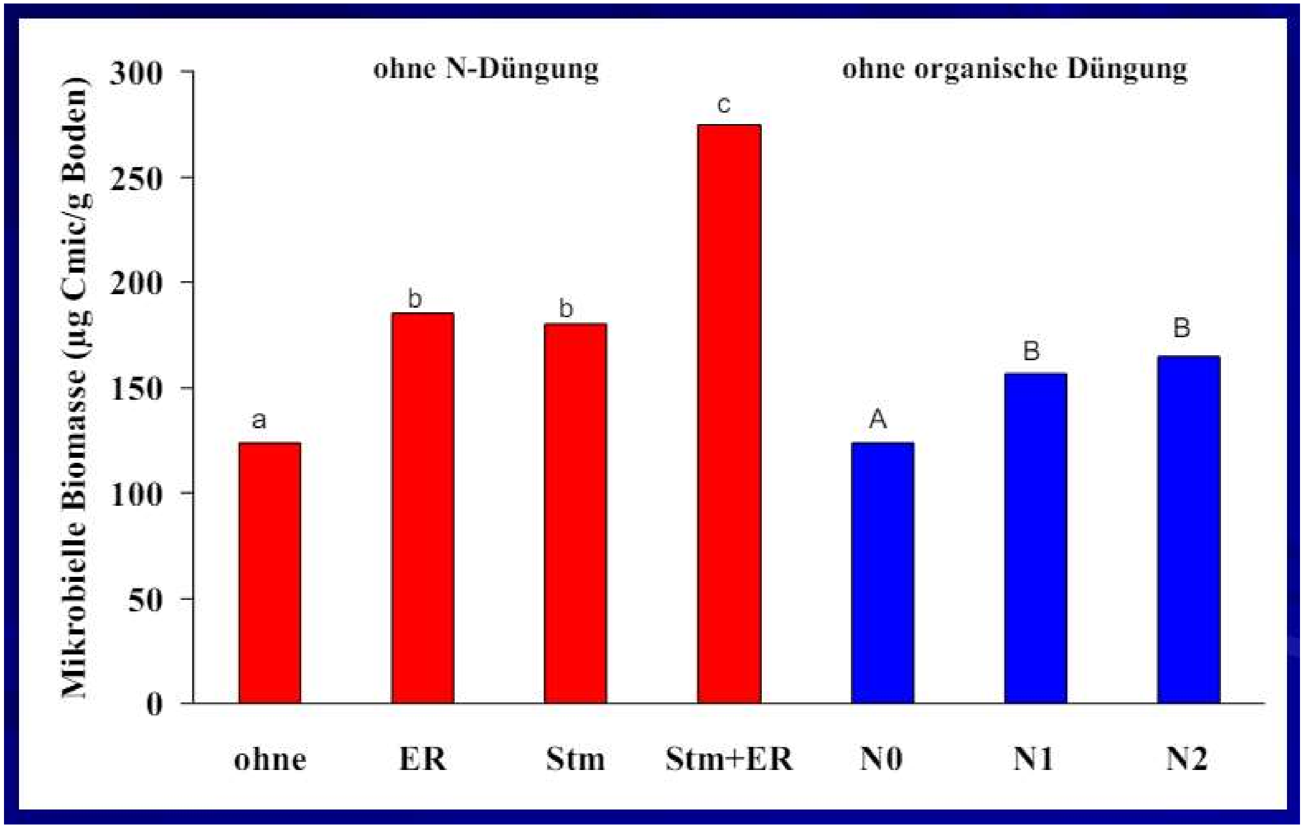
- Keeping biological productivity
- Storage and transfer of water and nutrients
- Decomposition of organic substances
- Detoxification of toxic compounds
- Supressing of phatogenes
- Sustaining water quality



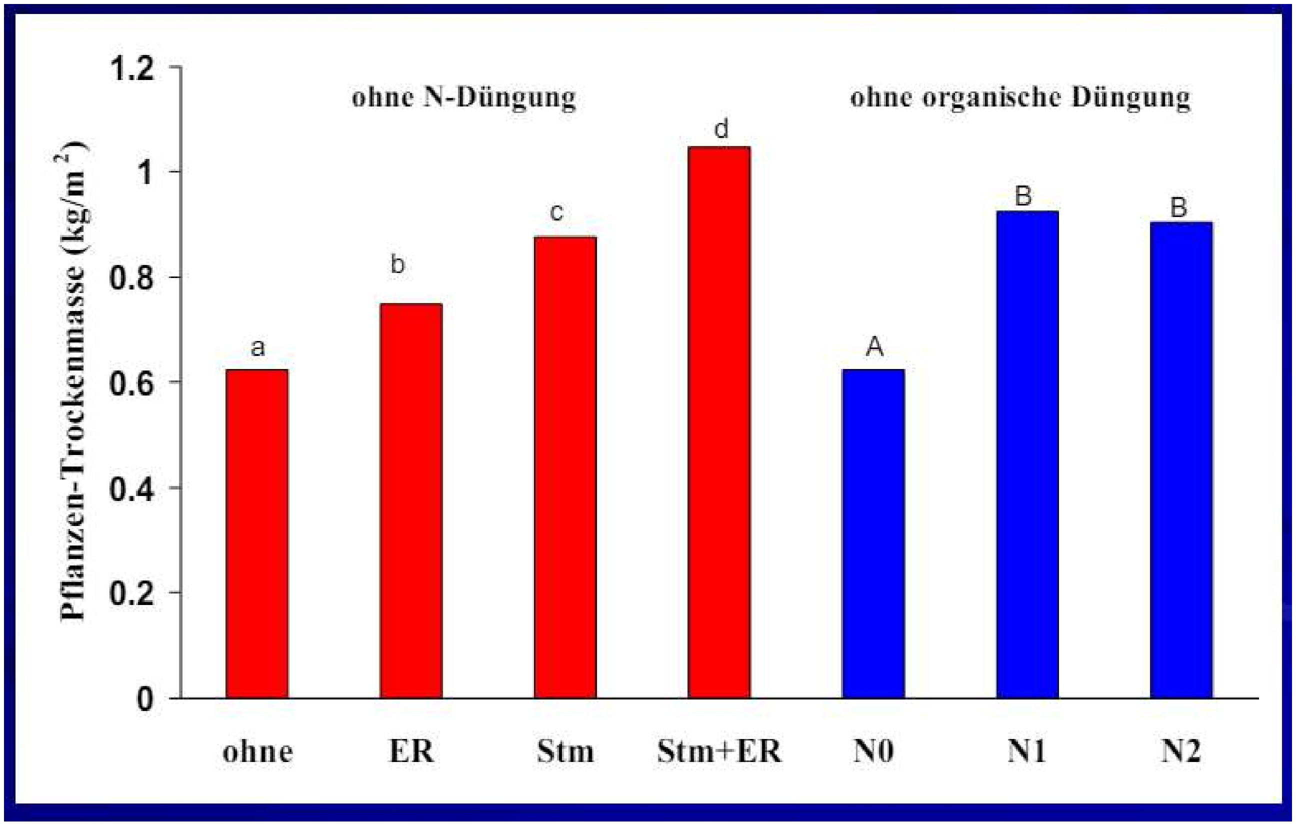
Microbial Indicators of soil health

- Microbial biomass
- Microbial activity
    - respiration, N-mineralization
- Enzymes
    - Urease, Dehydrogenase, Phosphatase, Sulfatase, Peptidase
- Microbial composition
    - Bacteria, fungy, Actinomycetae, Algae
- Microbial functional groups
    - Decomposers of cellulose, Nitrifier, Denitrifier, N_2-fixing bacteria, Pathogenes,
- Microbial community structure
    - Phylogenetic and functional diversity

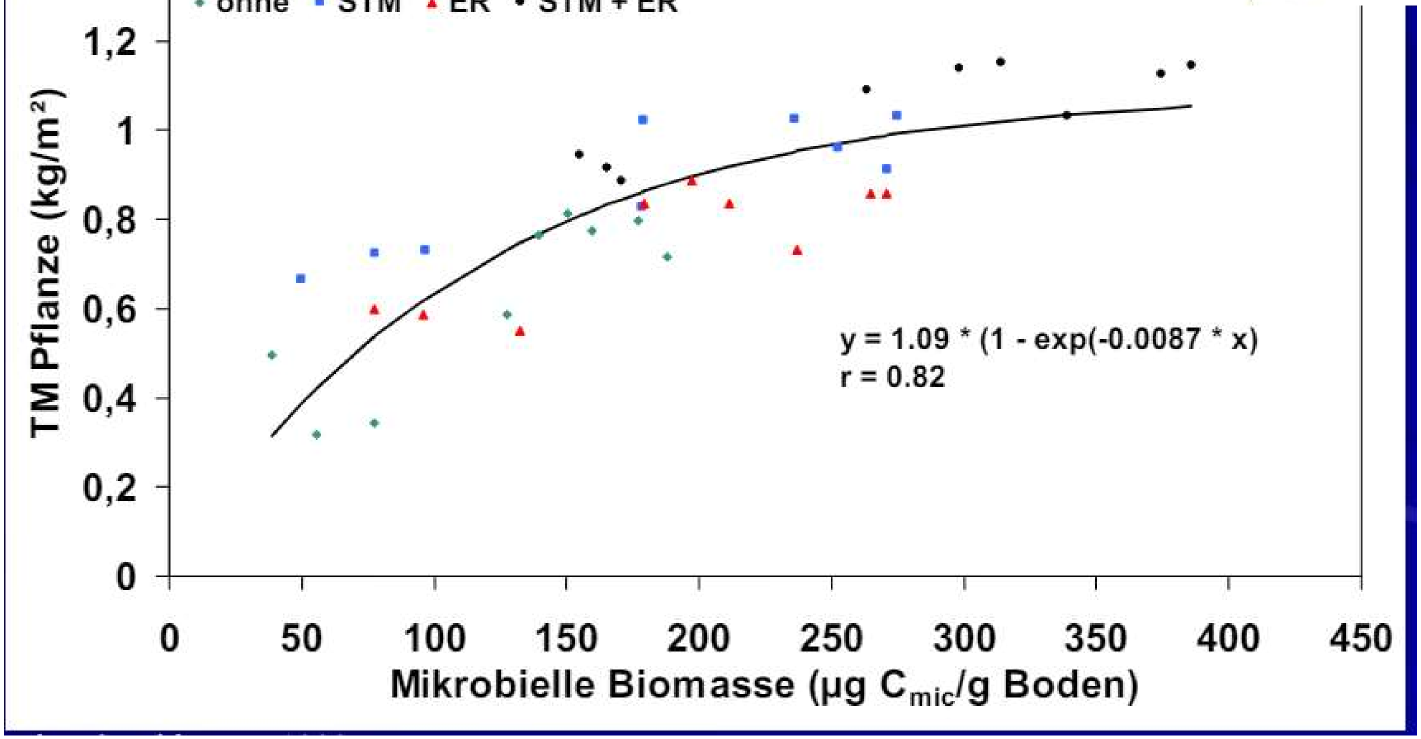
Long-term fertilization effect on soil microbial biomass in sandy soil



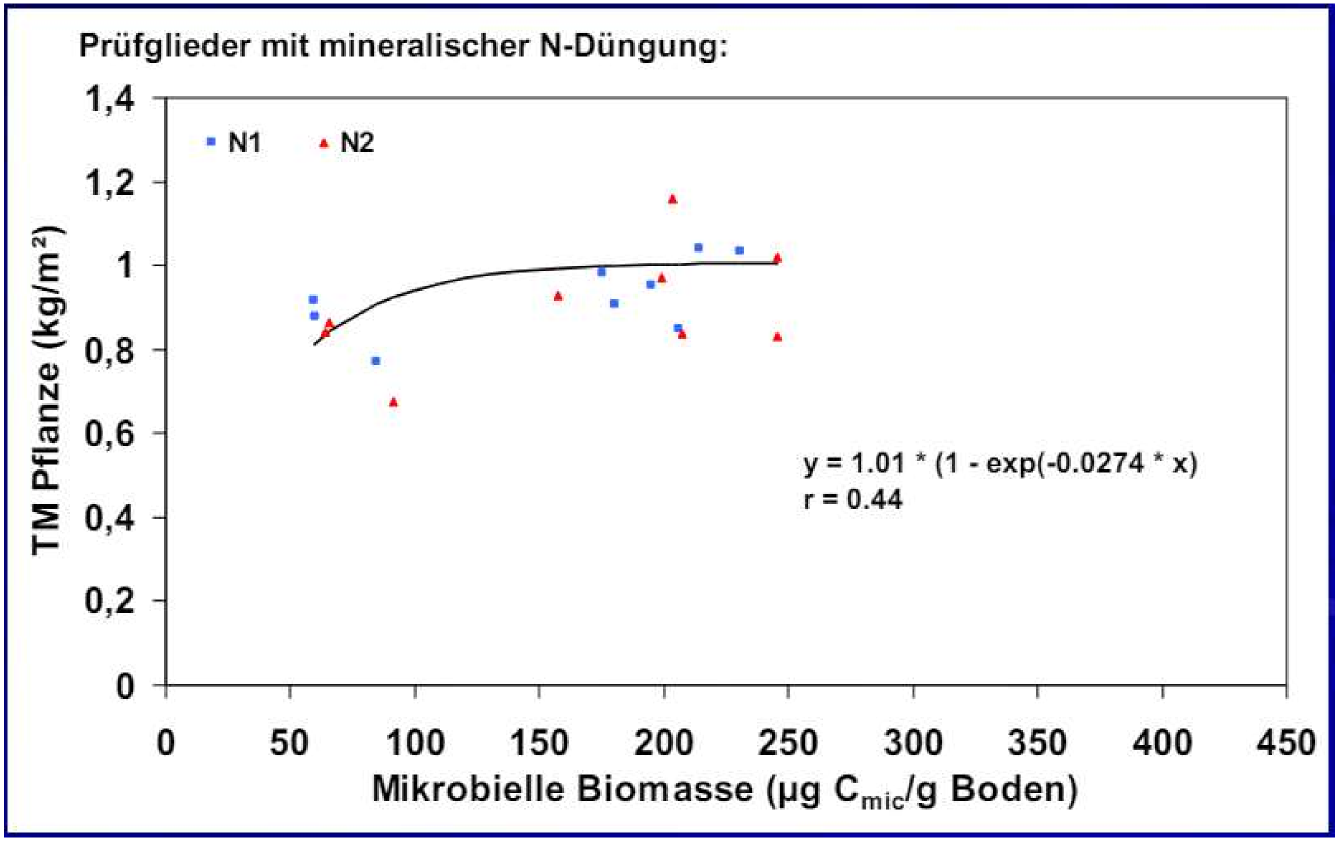
Long-term fertilization effect on carrot dry matter production



Relationship between plant growth and soil microbial biomass without mineral nitrogen fertilization



Relationship between plant growth and soil microbial biomass with mineral nitrogen fertilization



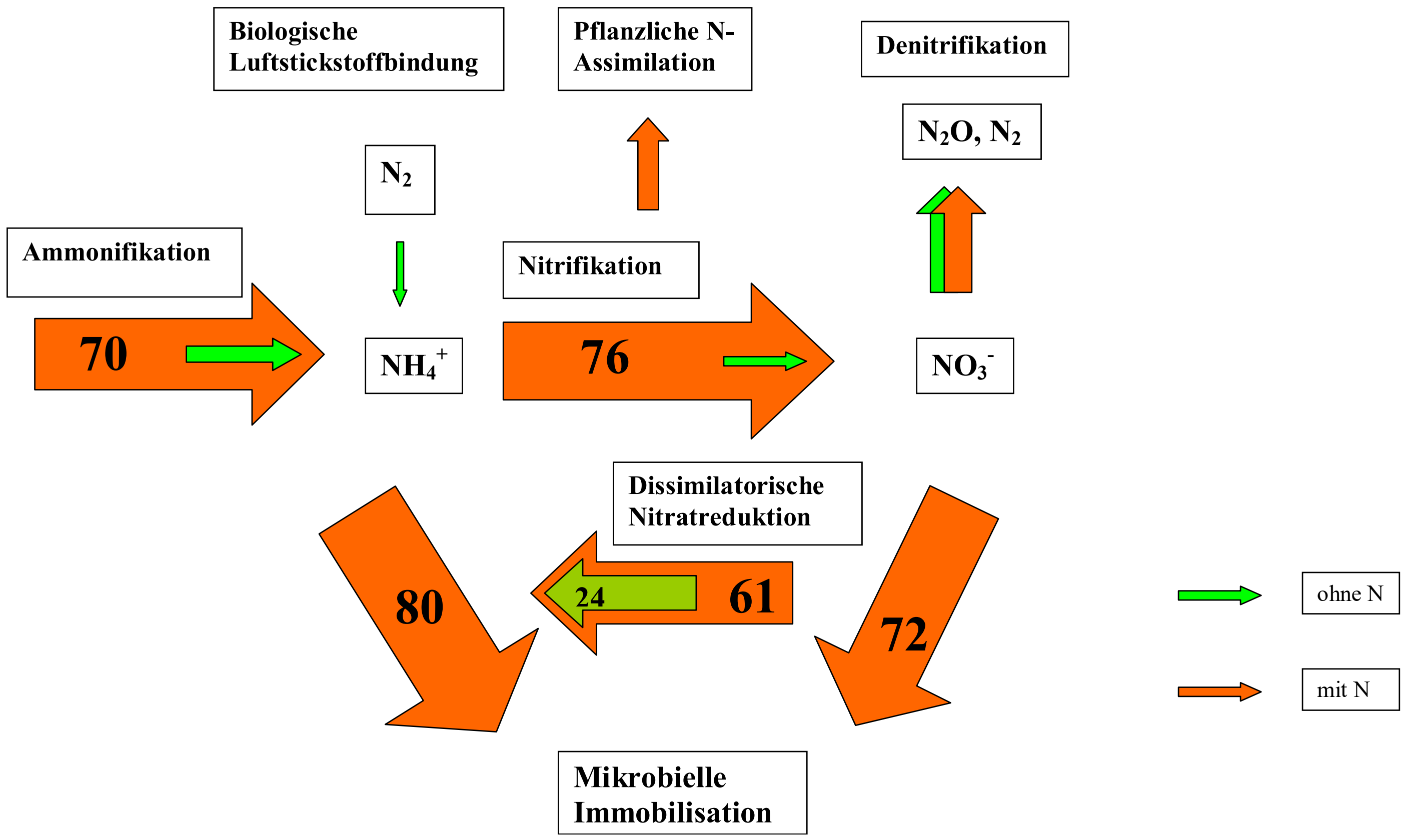
Yearly fluctuation of soil microbial biomass content under different land uses

crop reference	soil type/ location	microbial biomass C kg ha^{-1} (0-20 cm)		
		lowest	highest	fluct.
1. beech forest [1)]	acid brown earth/ Germany	530	760	230
2. wheat-soybean [2)]	Argiudoll Argentinia	1620	2340	720
3. winter wheat [3)]	clay soil U.K.	190	510	320
4. wheat soybean [4)]	silty clay loam Texas	1755	2295	540
5. cucum-ber [5)]	glayic cambisol Germany	675	1530	855

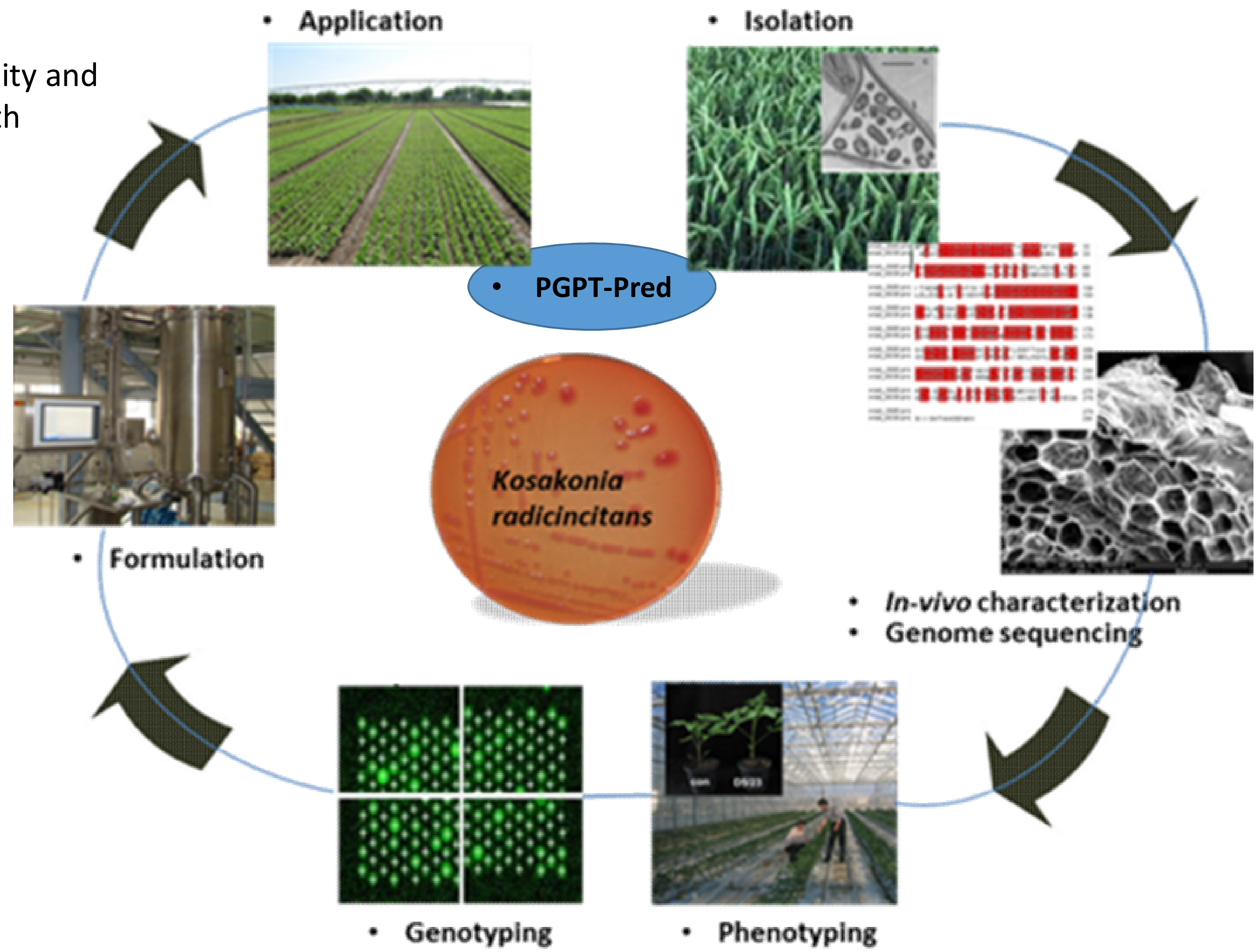
Nutrient release due to fluctuations in microbial biomass

crop	fluctuation Cmic (kg ha^{-1})	release of nitrogen (kg ha^{-1})	release of phosphate (kg ha^{-1})
1. beech forest	230	23	14
2. wheat-soybean	720	72	43
3. winter wheat	320	32	19
4. wheat soybean	540	54	32
5. cucum-ber	855	85	51

Potential nitrogen transfer rates (in kgN ha^{-1} d^{-1}) without and with nitrogen fertilization in model and field experiments

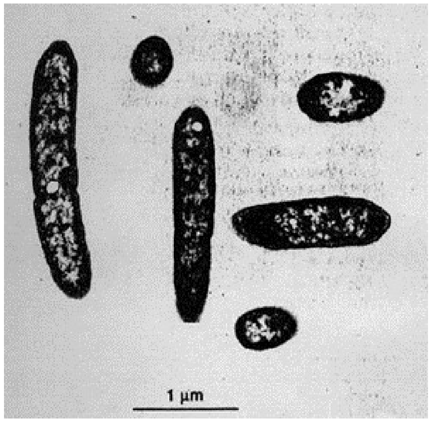


Microbial community and plant health/growth



New species PGPB *K. radicincitans* sp. DSM 16656

- *radicincitans* L.n.: a rod promoting root growth of plants
- Gram negative spherical/coccoid short rods, width 0.8-1.2 µm, length 1.0-1.6 µm
- Isolated from the phyllosphere of winter wheat



Ruppel et al. 1992, Plant Soil 145: 261-273
Kämpfer et al. 2005, Systematic Applied Microbiology 28: 213-221

Aim:

- Easy and cheap application procedure
  - Seed treatment
- Application in agricultural production
  - Spraying
- Increasing plant yield

AbiVital®

Berger, B.; Patz, S.; Ruppel, S.; Dietel, K.; Faetke, S.; Junge, H.; Becker, M. 2018: Successful formulation and application of plant growth-promoting *Kosakonia radicincitans* in maize cultivation. BioMed Research International. Volume 2018, Article ID 6439481, 8 pages https://doi.org/10.1155/2018/6439481

Growth-Promotion in Crops and Model Plants

Solanum lycopersicum

Capsicum annuum

Raphanus sativus var. sativus

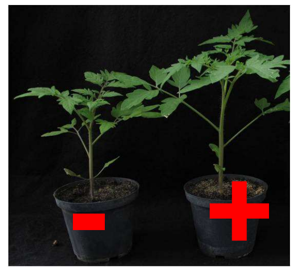
Arabidopsis thaliana

- Similar growth-promoting effects were observed for wheat (*Triticum aestivum*), maize (*Zea mays*), rape seed (*Brassica napus*), kohlrabi (*Brassica oleracea*) and even in Arabidopsis cultivars
- Trails in greenhouse, growth chamber and field

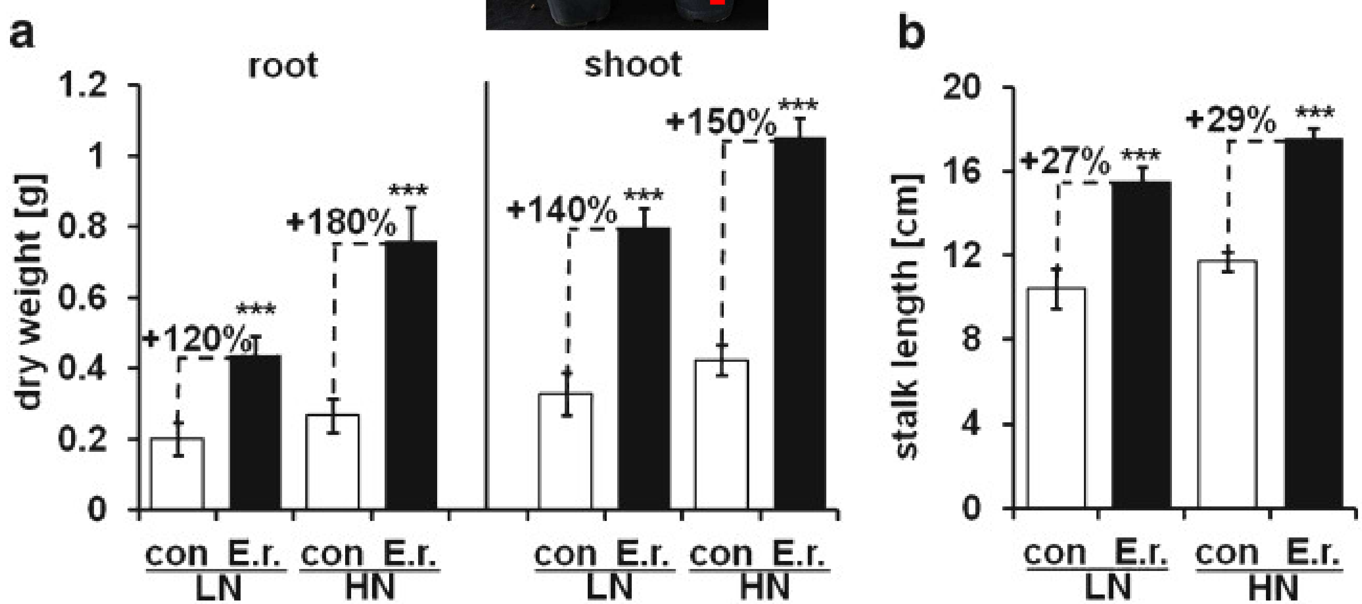
Greenhouse inoculation experiments tomato

Berger, B.; Patz, S.; Ruppel, S.; Dietel, K.; Faetke, S.; Junge, H.; Becker, M. 2018: Successful formulation and application of plant growth-promoting *Kosakonia radicincitans* in maize cultivation. BioMed Research International. Volume 2018, Article ID 6439481, 8 pages https://doi.org/10.1155/2018/6439481

Tomato plant growth-promotion *K. radicincitans*

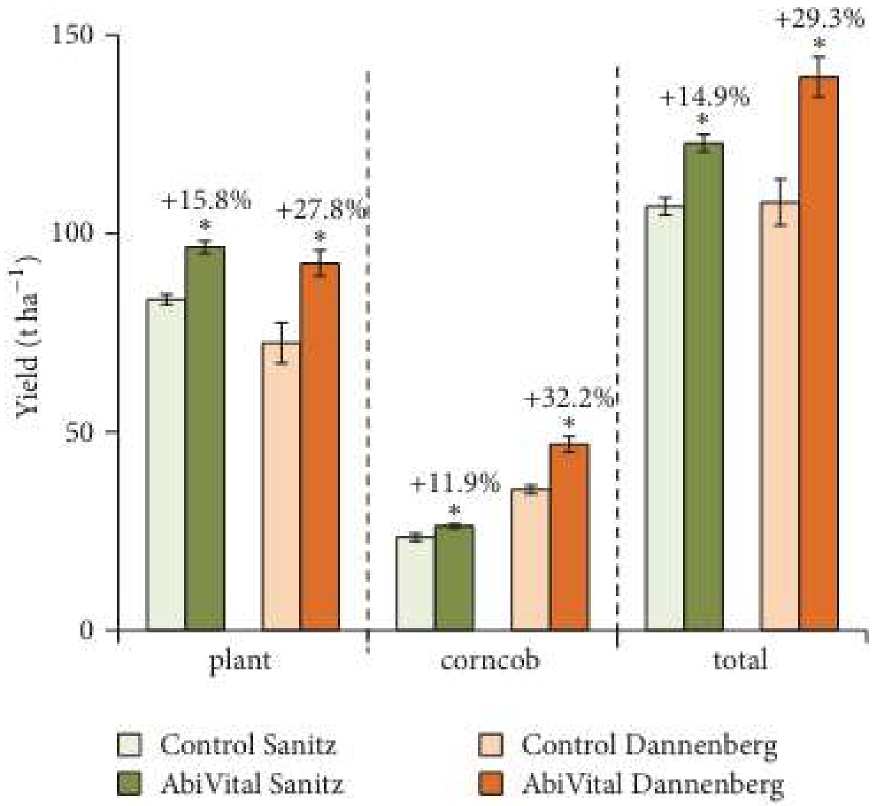


Solanum lycopersicum



Berger, B.; Brock, A.K.; Ruppel, S. 2013: Nitrogen supply influences plant growth and transcriptional responses induced by *Enterobacter radicincitans* in *Solanum lycopersicum*. Plant and Soil 370 (1-2): 641-652. DOI: 10.1007/s11104-013-1633-0

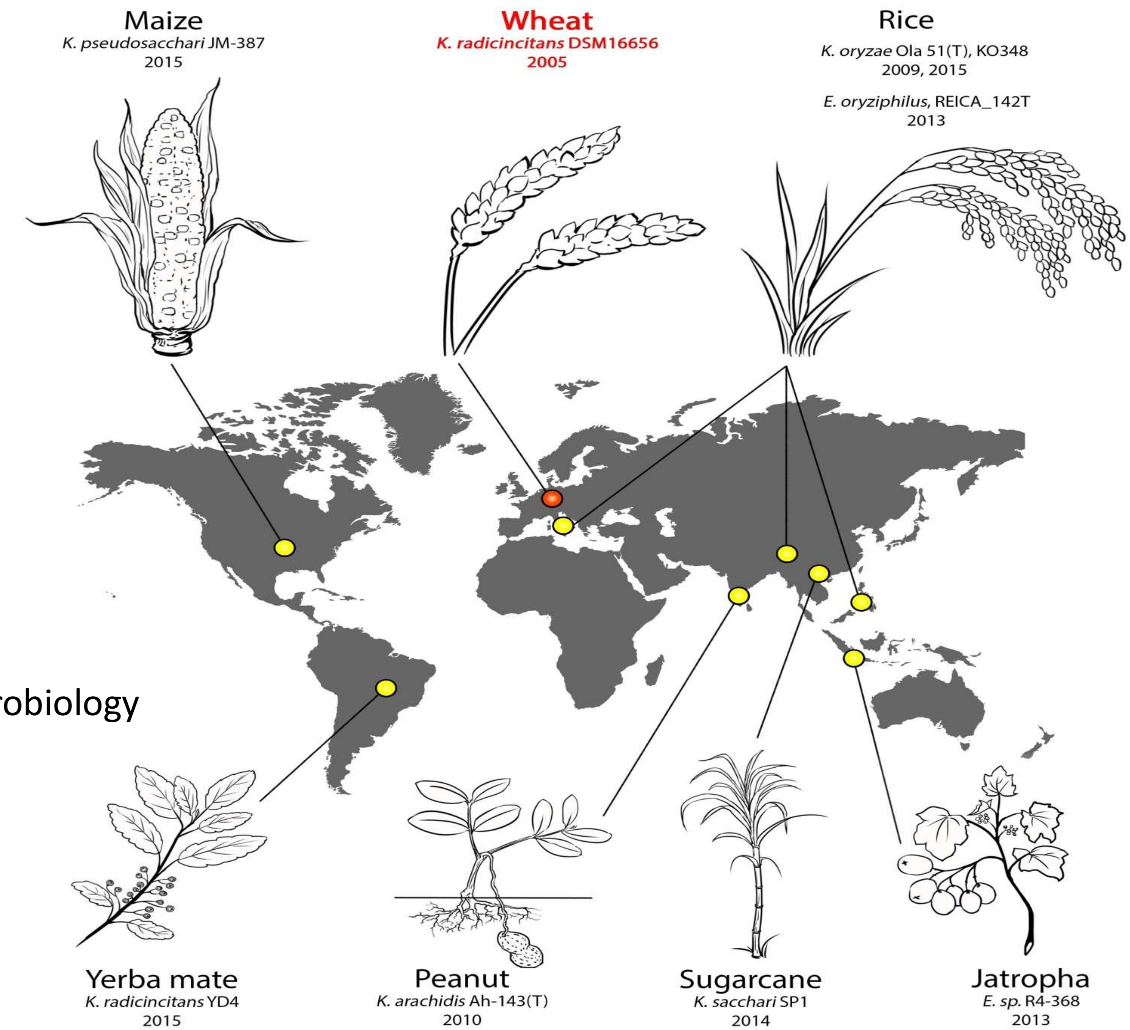
Yield of silage maize in Sanitz (Mecklenburg-West Pomerania) and Dannenberg (Lower Saxony).



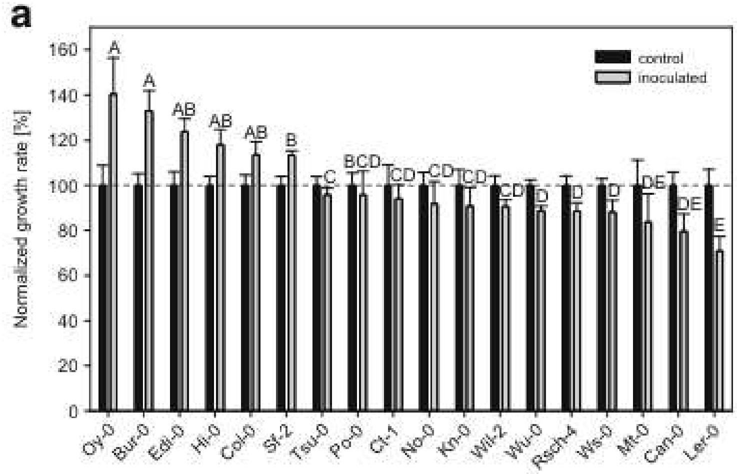
Berger et al. 2018 BioMed Research International
https://doi.org/10.1155/2018/6439481

Discovered *Kosakonia* and closely related strains worldwide showing yield increases in different crop plants

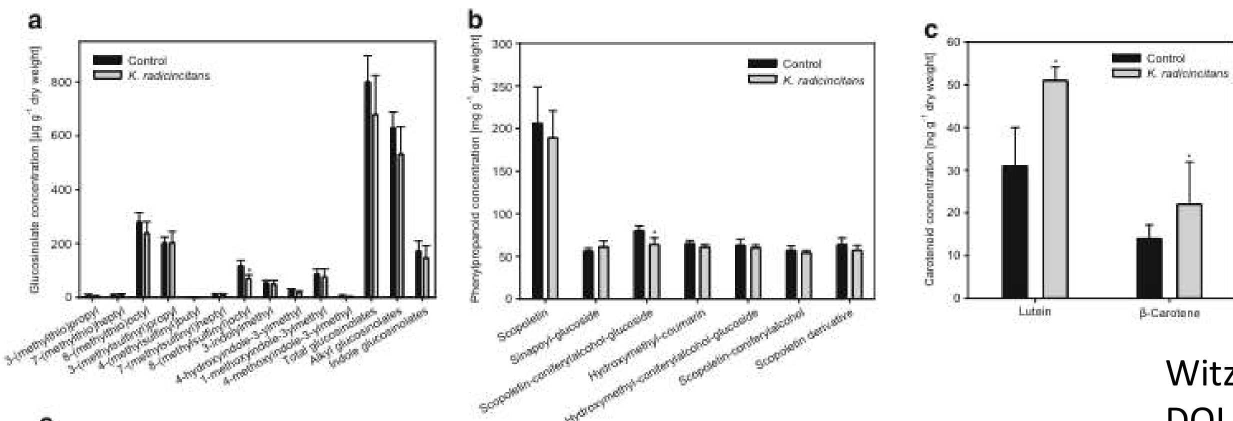
Becker et al. 2018, Frontiers in Microbiology
Doi:10.3389/fmicb.2018.01997



Relative growth of *Arabidopsis thaliana* accessions grown in the presence or absence of *K. radicincitans*

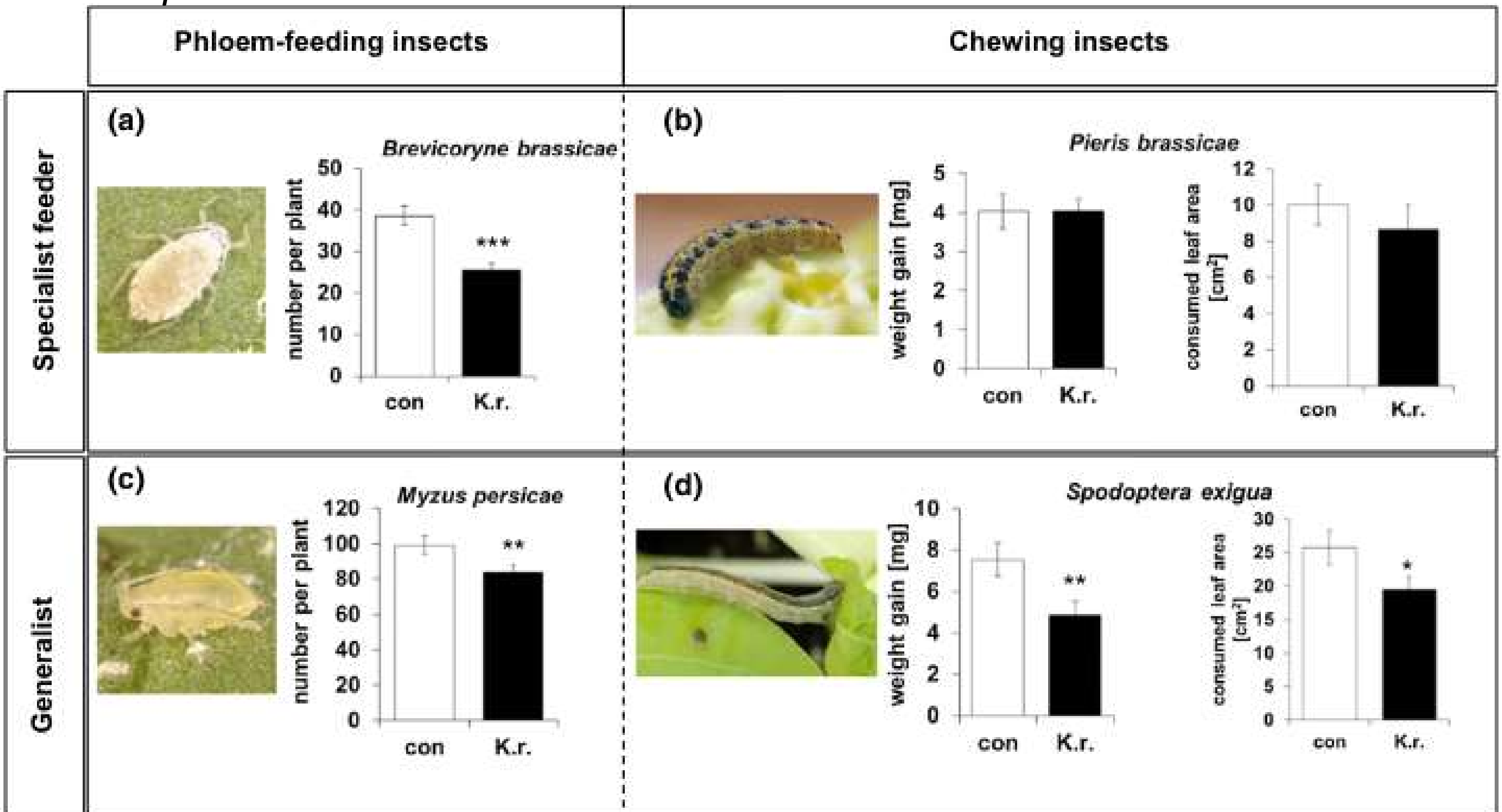


The decline in glucosinolates (a) and phenylpropanoids (b) and the induction of carotenoids (c) by *K. radicincitans* colonization in *A. thaliana* roots



Witzel et al. 2017 Plant and Soil
DOI 10.1007/s11104-017-3371-1

Impact of plant growth-promoting bacteria *Kosakonia radicincitans* on insect performance in *Arabidopsis thaliana*

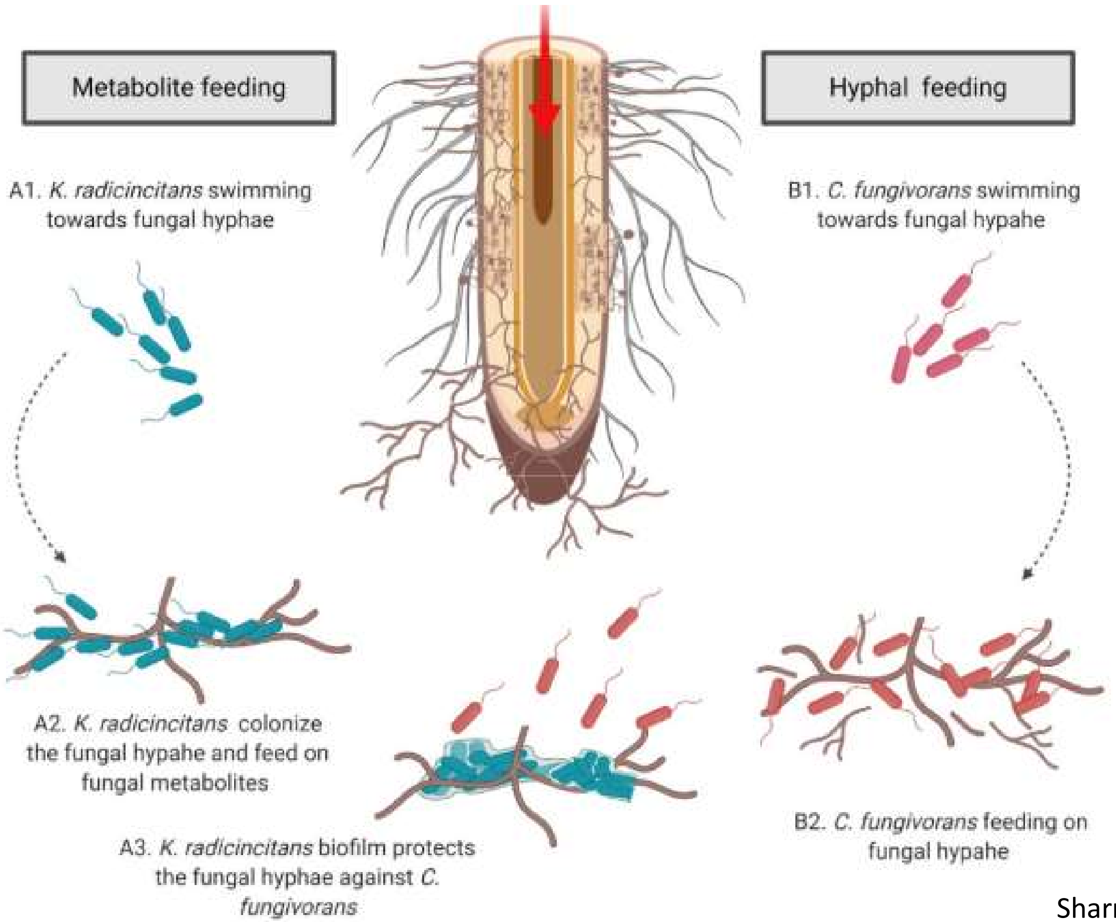


We found that the jasmonic acid pathway is relevant for upregulation of aliphatic glucosinolates and suppression of the chewing generalist S. exigua larval growth.

Brock et al. 2018 Planta
https://doi.org/10.1007/s00425-018-2964-0

salicylic acid (npr1-1 mutant) or jasmonic acid (coi1-1 mutant) pathway

A conceptual model of hyphal protection and bacterial feeding strategies employed by the PGPB *Kosakonia radicincitans* and the fungus feeding bacterium *Collimonas fungivorans*



Sharma et al. 2021, Microorganisms
https://doi.org/10.3390/microorganisms9081566

Herzlichen Dank