GHENT UNIVERSITY

FACULTY OF BIOSCIENCE ENGINEERING

bacterially enhanced plant growing media for controlled environment agriculture.

Thijs Van Gerrewey – Cropib – 28 Mar 2022

HortiCell CMET URBAN CROP SOLUTIONS Agaris GROUP

Cropfit AGENTSCHAP INNOVEREN & ONDERNEMEN

bacterially enhanced plant growing media for controlled environment agriculture.

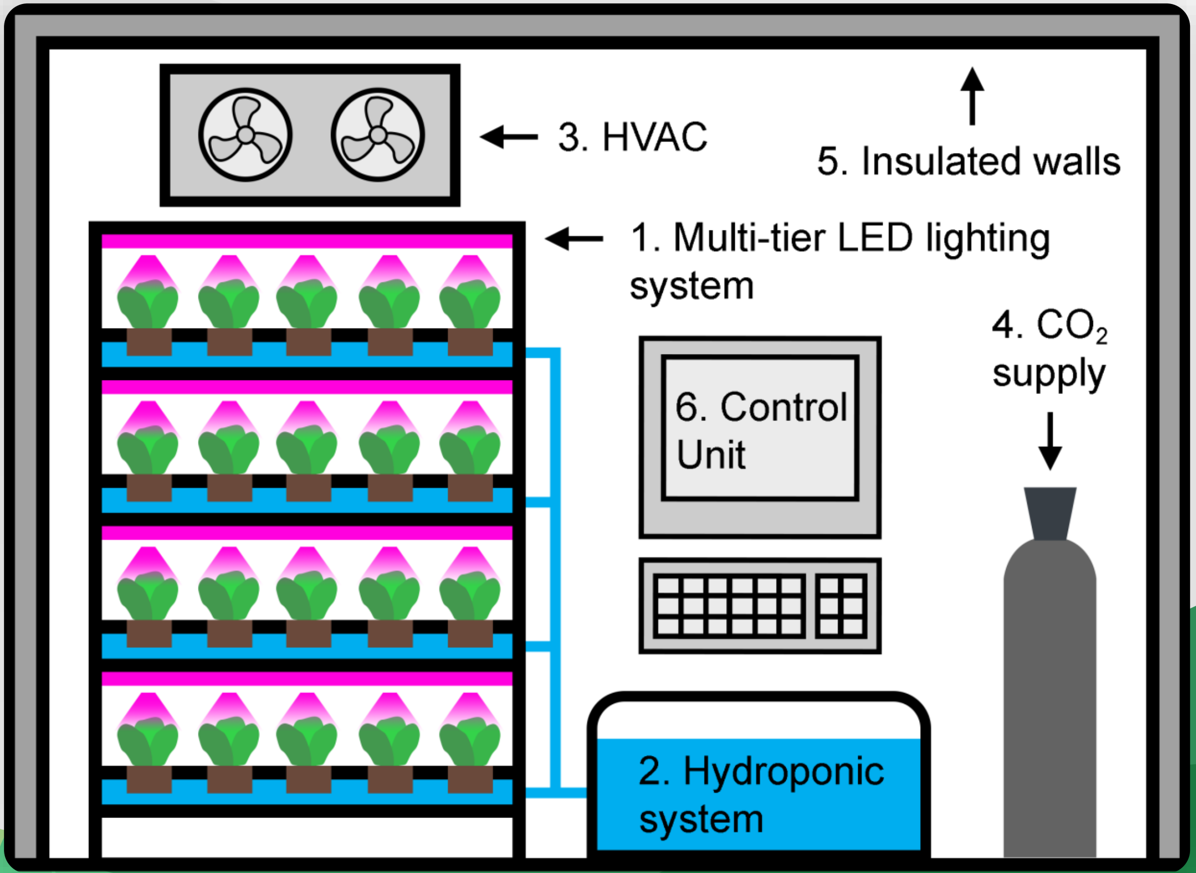
timeline.

- controlled environment agriculture
- plant growing media
- bacteria

vertical farm.

"a **multilayer indoor** plant production system in which all growth factors are **precisely controlled** to produce high quantities of high-quality fresh produce **year-round**, completely **independent** of solar light and other outdoor conditions."

SharathKumar et al. (2020)



Van Gerrewey et al. (2021) Vertical Farming: The Only Way Is Up?

a brief history.

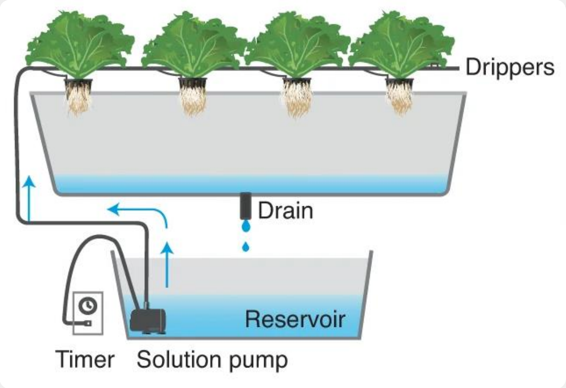
Suske en Wiske, Op het eiland Amoras, Willy Vandersteen, Standaard Uitgeverij (1945)

L. Zotter, Österreichisches Gartenbaumuseum (1964)

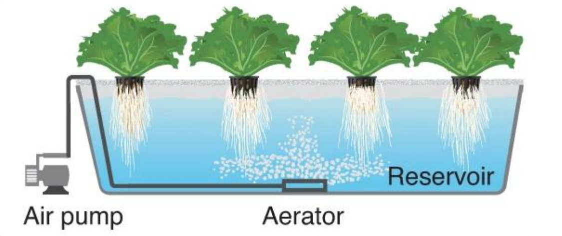
Van Gerrewey et al. (2021) Vertical Farming: The Only Way Is Up?

hydroponics.

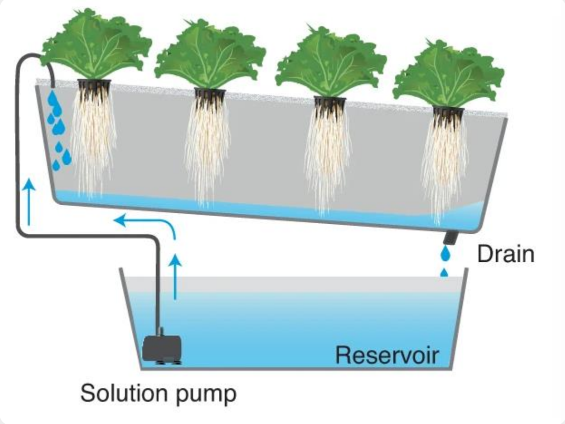
drip system



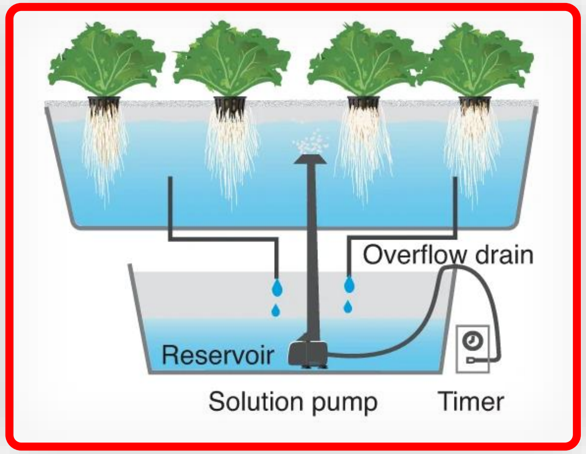
deep water culture



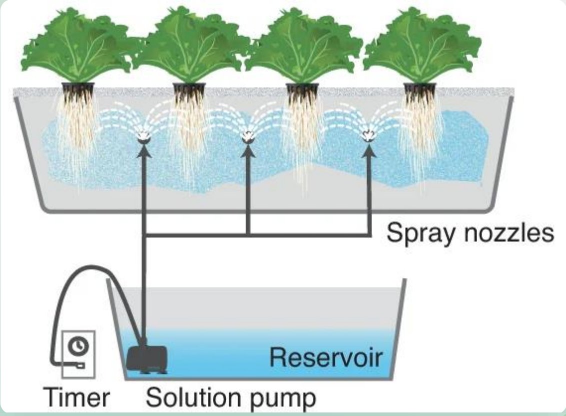
nutrient film technique



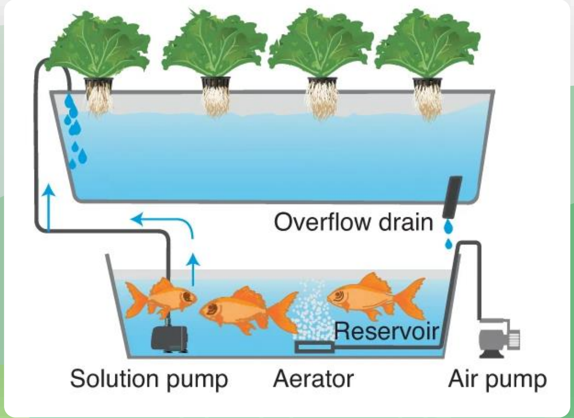
flood and drain



aeroponics



aquaponics



van Delden et al. (2021)

led grow lights.

efficient energy conversion and less heat dissipation

manipulate the light spectrum, intensity, and timing

the need for niche expansion.

vertical farming will become a sustainable addition to agriculture

- water use, food mileage, food security
- renewable energy

high costs → only profitable in specific niche markets

- geographical
- added value

niches need to be expanded

- technological advancement
- plant biology

the need for support.

loss of physical structure for rooting

a growing medium provides:

- physical support
- optimal water/air ratio
- nutrient buffer capacity

a growing medium is:

- standalone material or mixture
- additives

growing medium performance: creating an ideal home for plant roots.

physical

- easily available water
- aeration

chemical

- pH
- nutrient buffering capacity
- nutrient content

biological

- phytosanitation
- biological breakdown
- nitrogen competition

environmental concerns of peat use.

peat properties

- sound performance, wide availability, and low cost

environmental concerns of peat use.

peat properties

- sound performance, wide availability, and low cost

sustainability of peat production

- CO_2 emissions and ecosystem damage
- responsible use and restoration of peatland
- peat-reduced future

environmental concerns of peat use.

organic materials

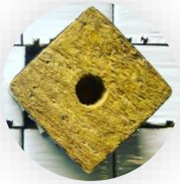
coir pith

wood fiber

composted bark

green waste compost

inorganic materials



mineral wool

perlite

sand

peat properties

- sound performance, wide availability, and low cost

sustainability of peat production

- CO_2 emissions and ecosystem damage
- responsible use and restoration of peatland
- peat-reduced future

alternative materials to the rescue?

plant growing media in the future.

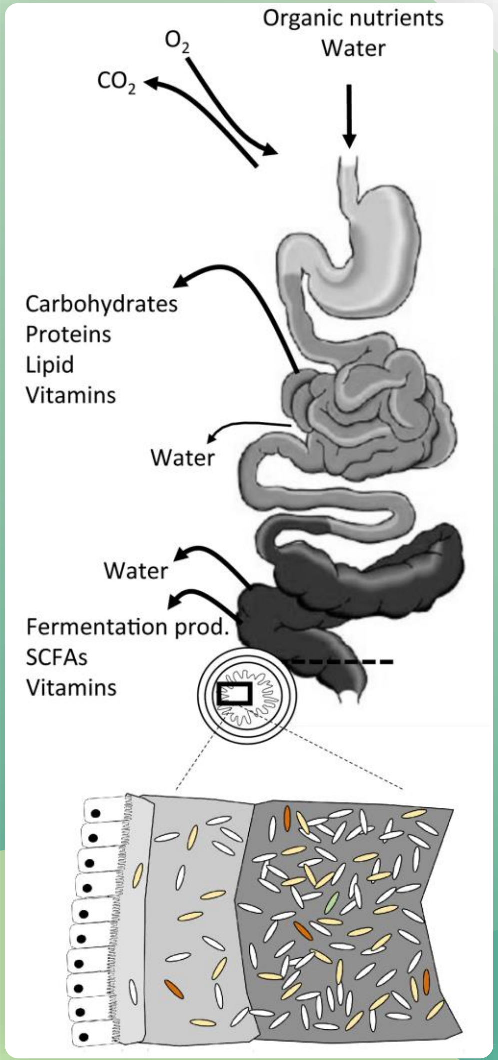
exponential increase in growing media use

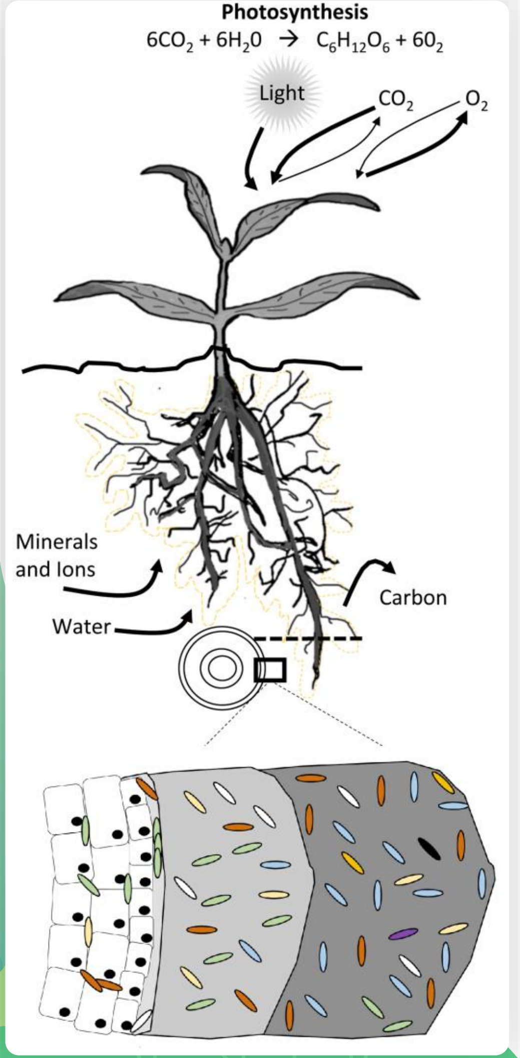
- more hydroponics, more growing media use
- development of new materials and blends

opportunity to create bacterially enhanced plant growing media

- positive role of microbiome is given little attention

the root microbiome:
the plant's gut microbiota.



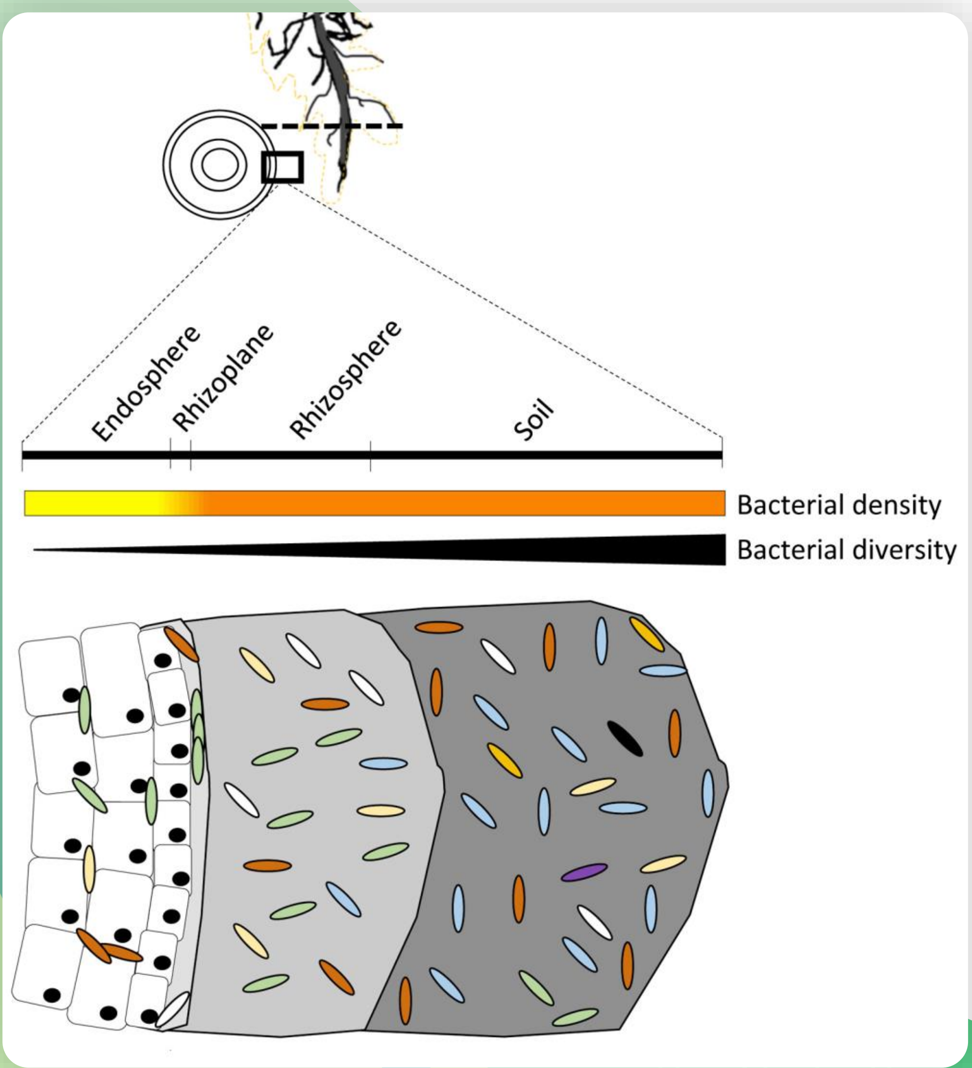


Hacquard et al. (2015)

host-associated microbiome

- nutrient availability
- protection against pathogens

the root microbiome:
the plant's gut microbiota.



Hacquard et al. (2015)

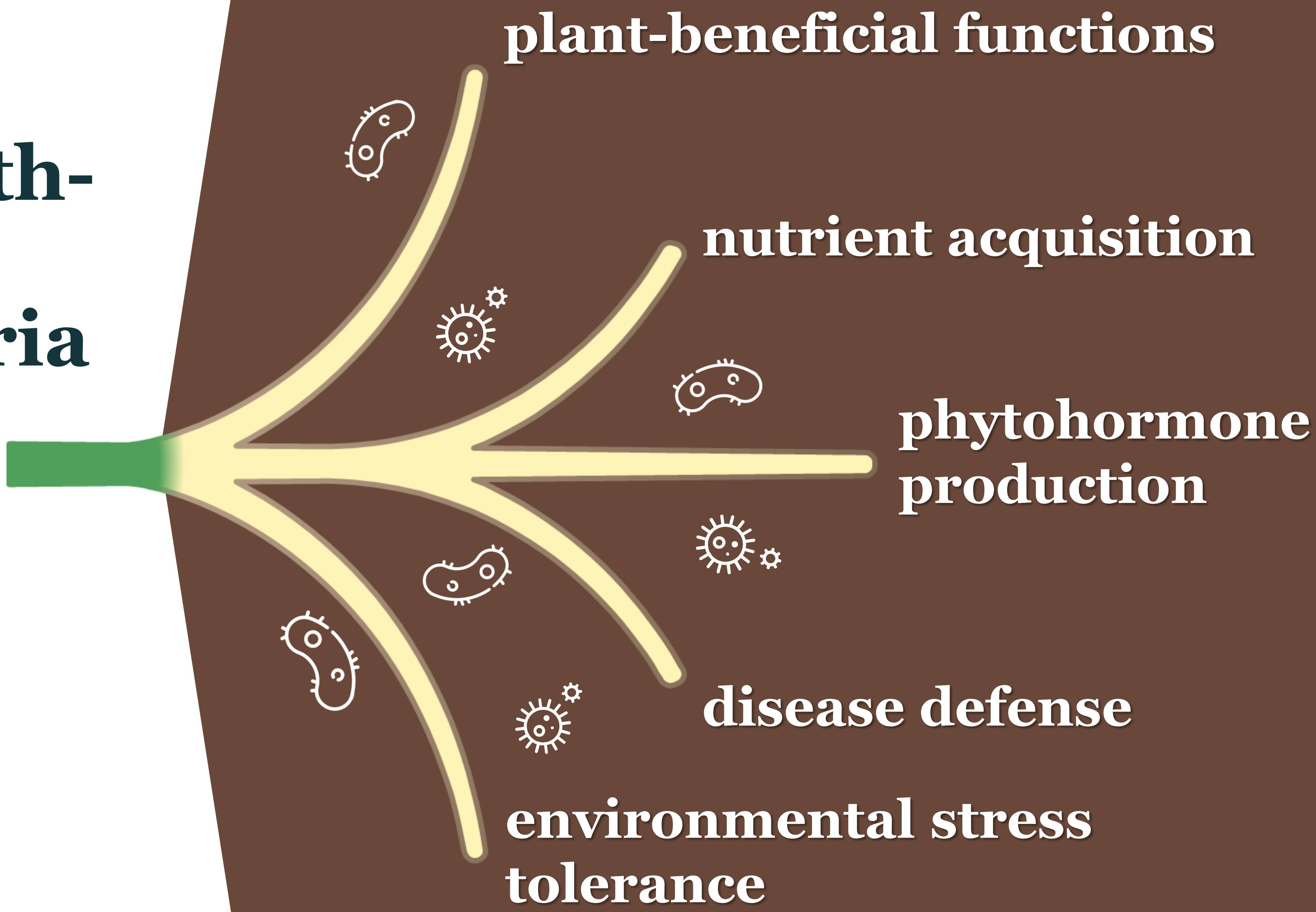
host-associated microbiome

- nutrient availability
- protection against pathogens

microbial gradient

- high density: 12 x world population or 8000 x Belgium
- decrease in diversity
- niche adaptation

plant growth-promoting rhizobacteria (PGPR).



bacterial amendment: an effective probiotic therapy?

from lab to field

single bacteria vs communities

- bacterial diversity and density
- microbiome multifunctionality

the root microbiome in hydroponics.

popular belief: hydroponic cultivation is sterile

- FALSE!
- creates a pathogen-vulnerable environment

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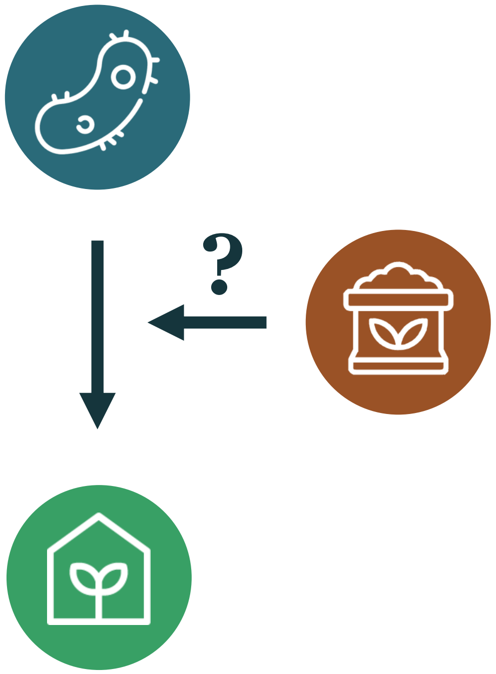
microbiome in organic growing media

- more diverse and competitive than inorganic
- multifunctional and environmental resilience

aims and objectives.



collection of lettuce root bacterial communities.

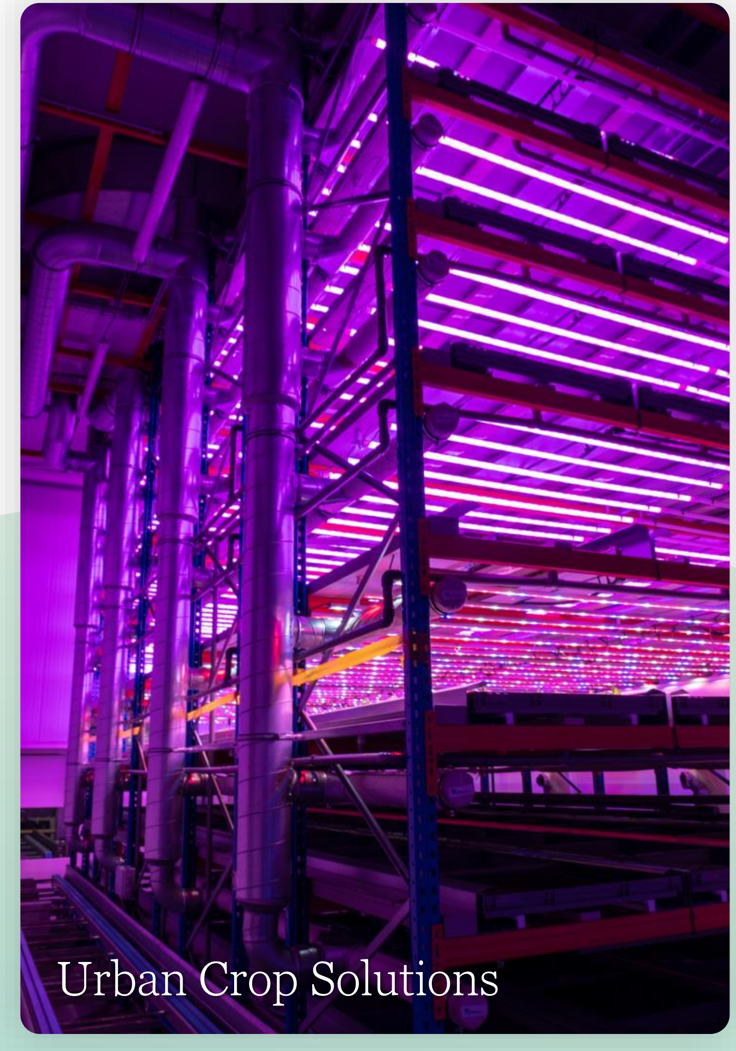
- 5 locations (S1-5): 3 organic soil and 2 hydroponics
- PGPR product: *Bacillus* sp.

growing media composition.

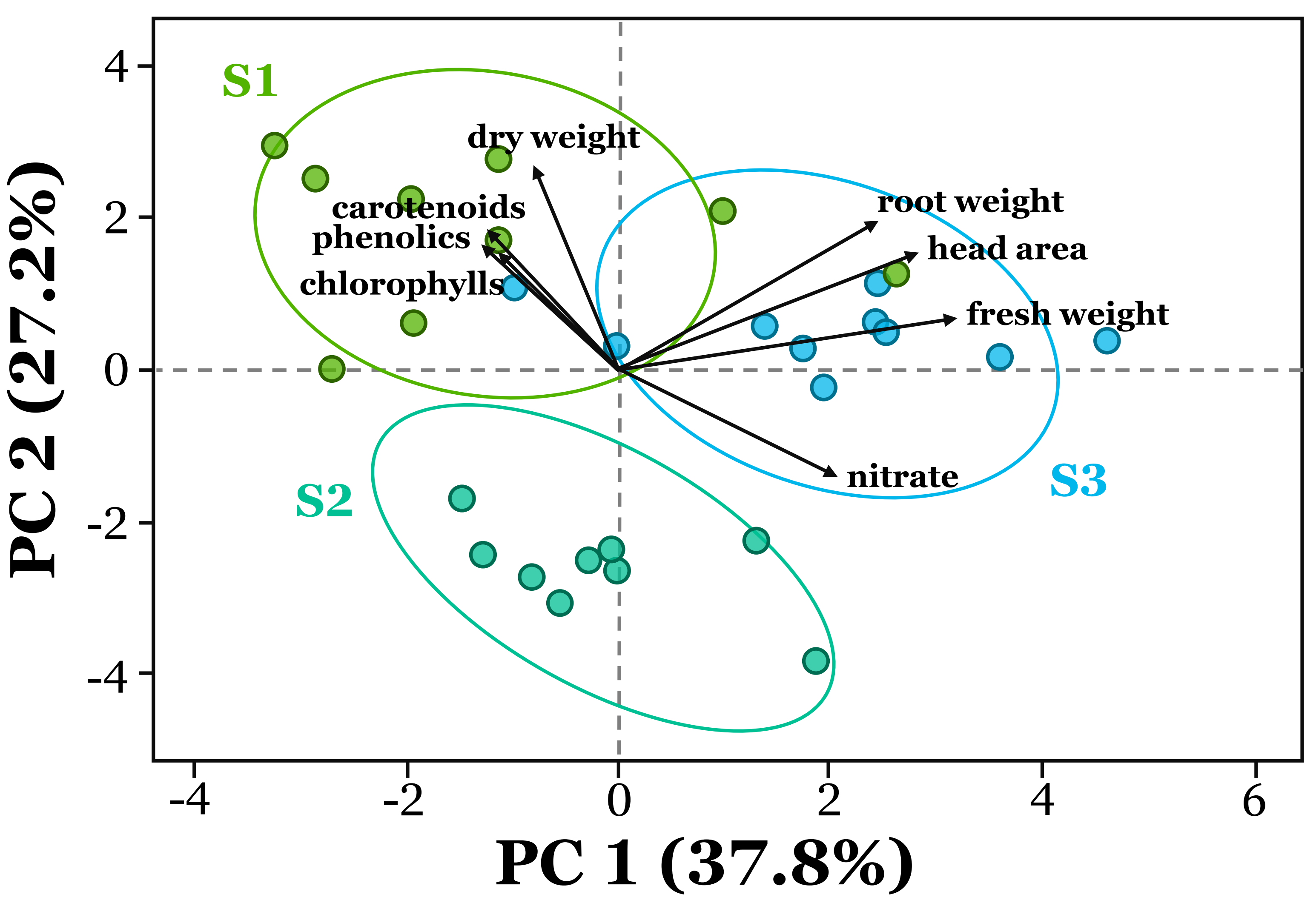
group	raw material	
peat (60%)	black	white
other organics (20%)	coir pith	wood fiber
composts (10%)	bark	green waste
inorganics (10%)	perlite	sand

- Factorial design
- 10 growing media mixtures (M1-10)

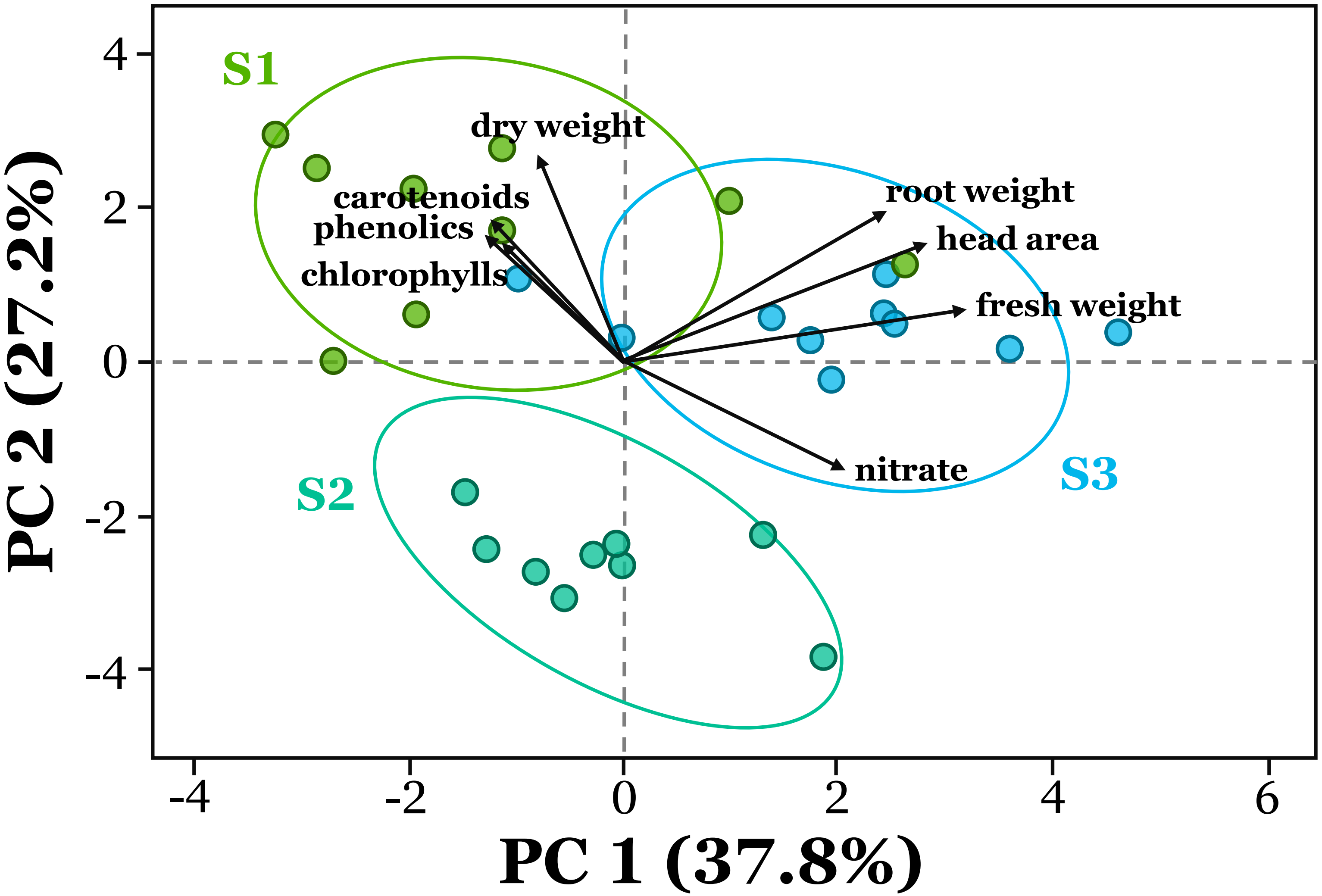
lettuce growth and bacterial amendment.



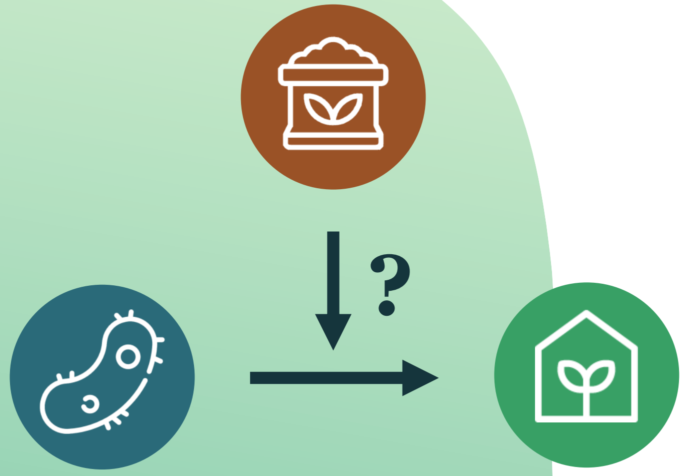
the effectiveness of bacterial amendment depends on the bacterial source...



...and microbe-growing medium interactions.

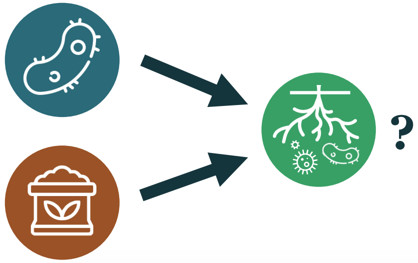


S3 vs control – fresh weight
M1
M2
M3
M4
$\boxed{\text{M5}}$
M6
M7
M8
M9
M10

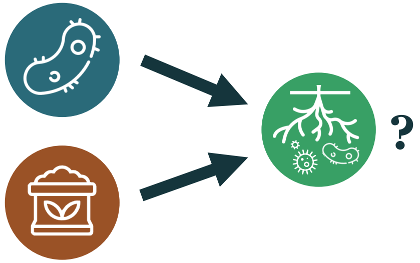


bacterial community amendments can be applied in controlled environment agriculture

- growing medium optimization is required

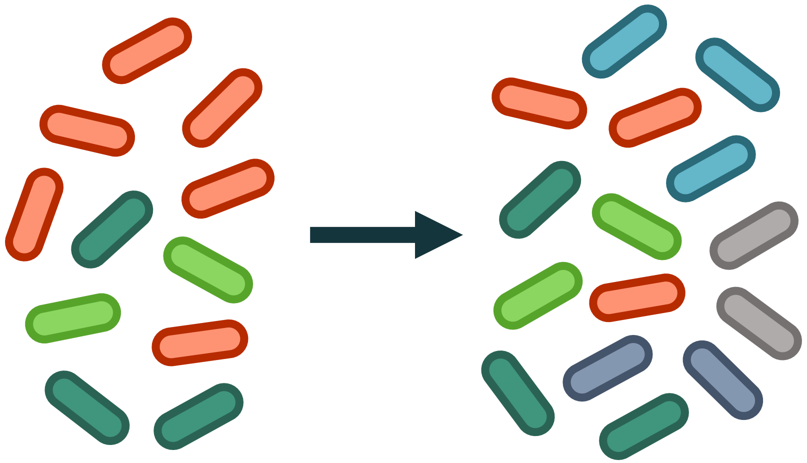


identification of root bacterial community.

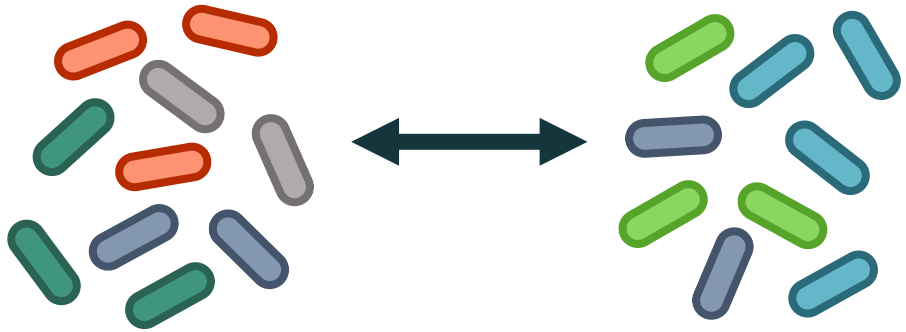


growing media composition steers root bacterial community…

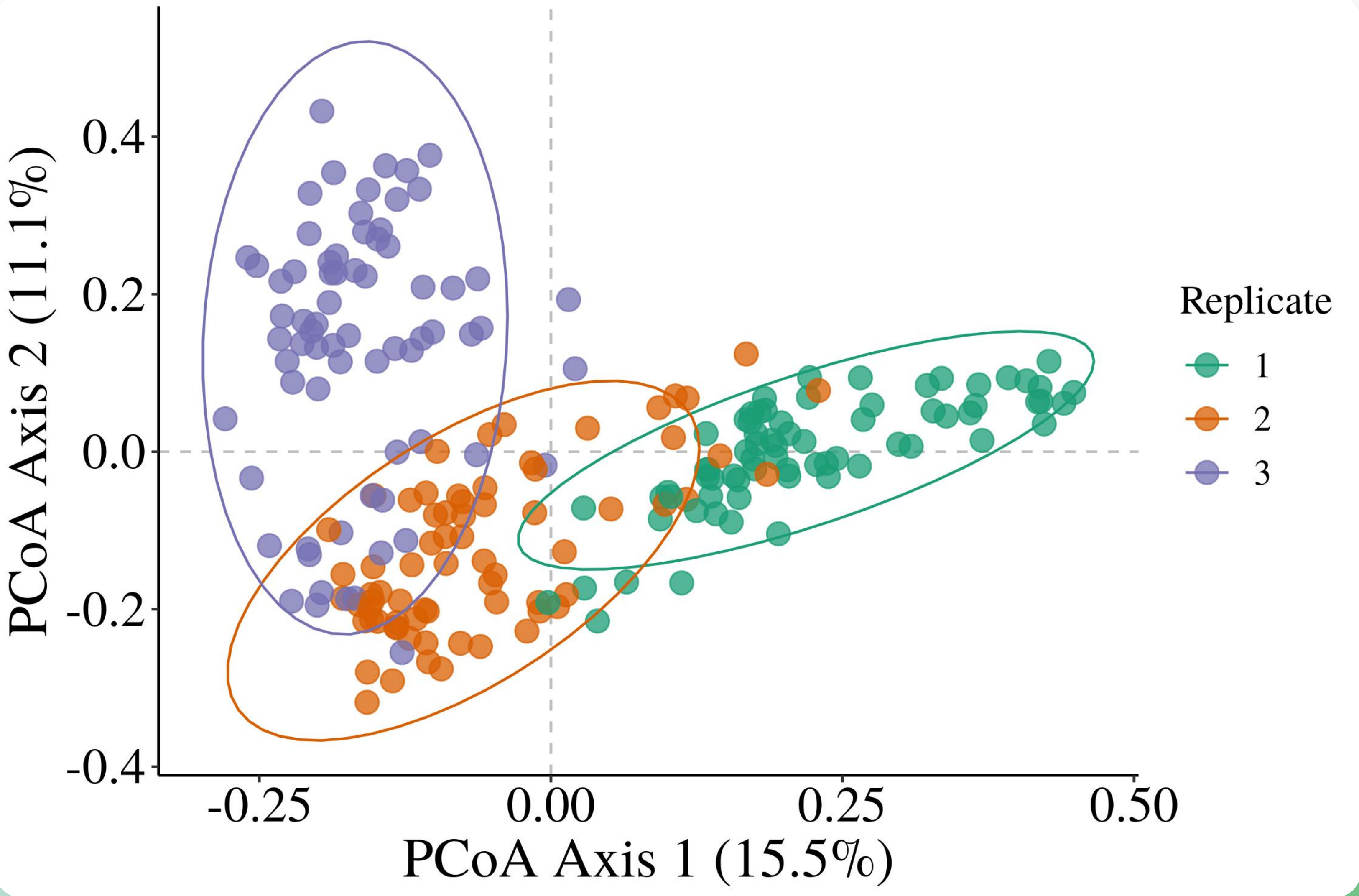
peat	white	→	black
other organics	coir pith	→	wood fiber
composts	bark	→	green waste

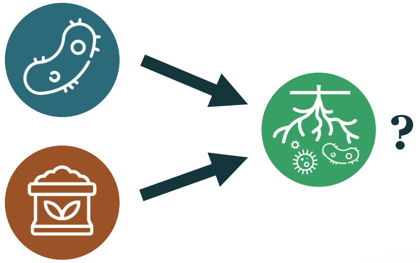


	bacterial community structure		
peat	black	↔	white
other organics	coir pith	↔	wood fiber
composts	green waste	↔	bark
inorganics	perlite	≈	sand

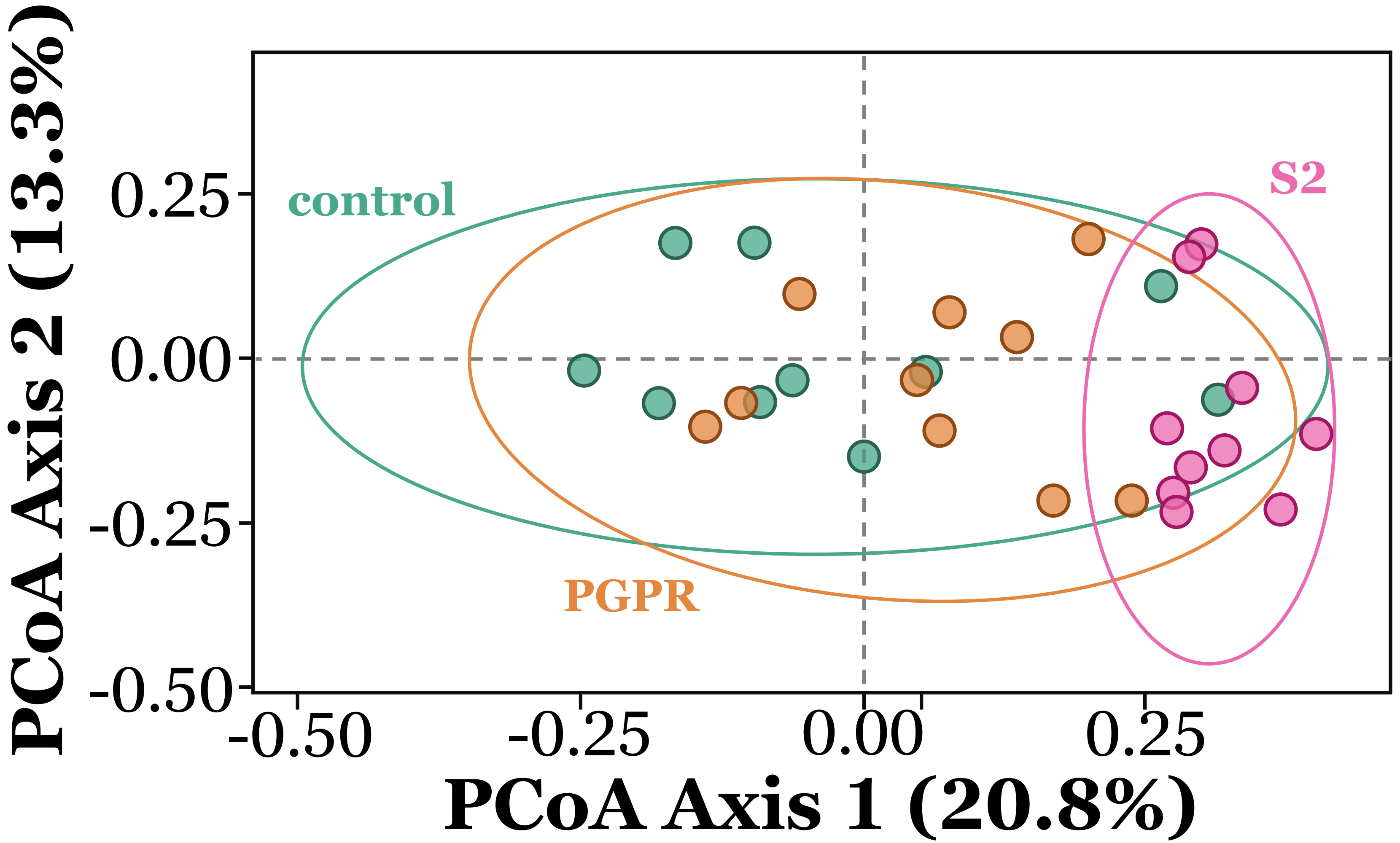


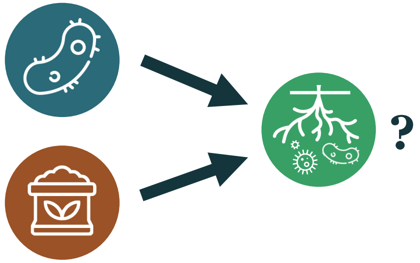
...even at batch level.





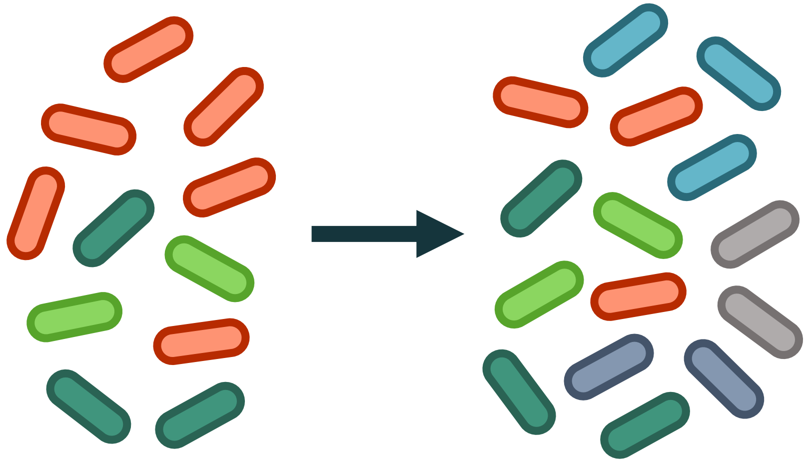
bacterial community amendment allows more control.





high bacterial diversity promotes plant performance.

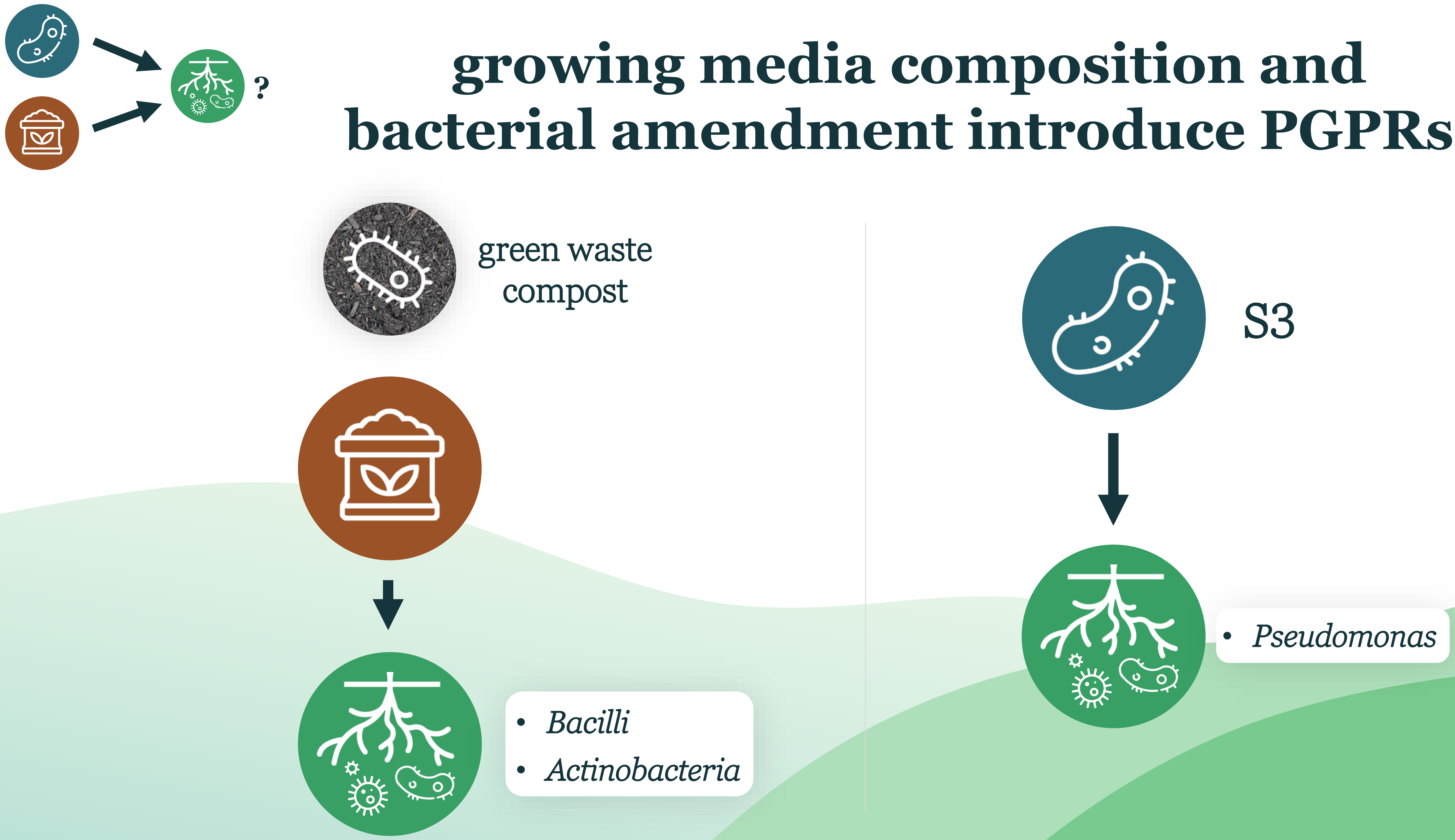
composts	bark	→	green waste
amendment	control	→	S3

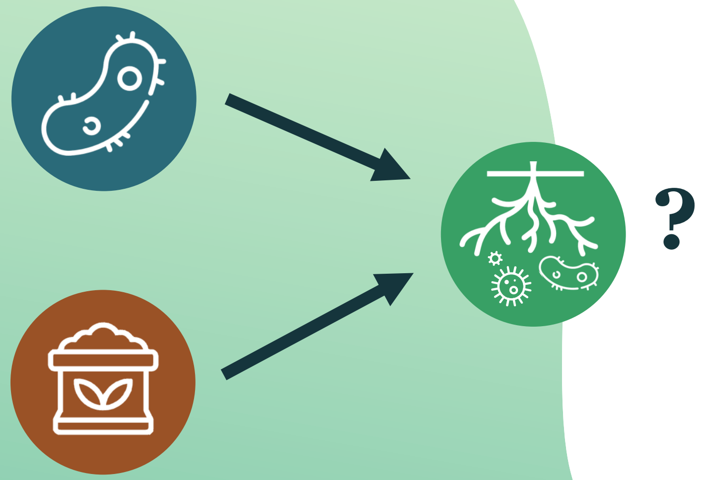


				yield
composts	bark	→	green waste	+
amendment	control	→	S3	+

	diversity	
	richness	Shannon
fresh weight	0.20	0.38
head area	0.18	0.42
root weight		0.28

growing media composition and bacterial amendment introduce PGPRs.





bacterial community composition of growing media is highly variable

bacterial community amendment allows more control over the root zone

- introduce more diversity → plant performance
- introduce PGPRs

lessons useful for the industry.

redefining biological performance of growing media

- include multifunctionality and resilience to environmental changes

multifunctional PGPRs can improve plant growth and quality in controlled environment agriculture

- hydroponics is not sterile
- take advantage of microbial diversity in the root zone

thank you!

HortiCell
Prof. Danny Geelen

CMET
Prof. Nico Boon

URBAN CROP SOLUTIONS

Agaris GROUP

Cropfit
Maaike Perneel

AGENTSCHAP INNOVEREN & ONDERNEMEN

- Email: thijs.vangerrewey@ugent.be
- LinkedIn: www.linkedin.com/in/thijsvangerrewey