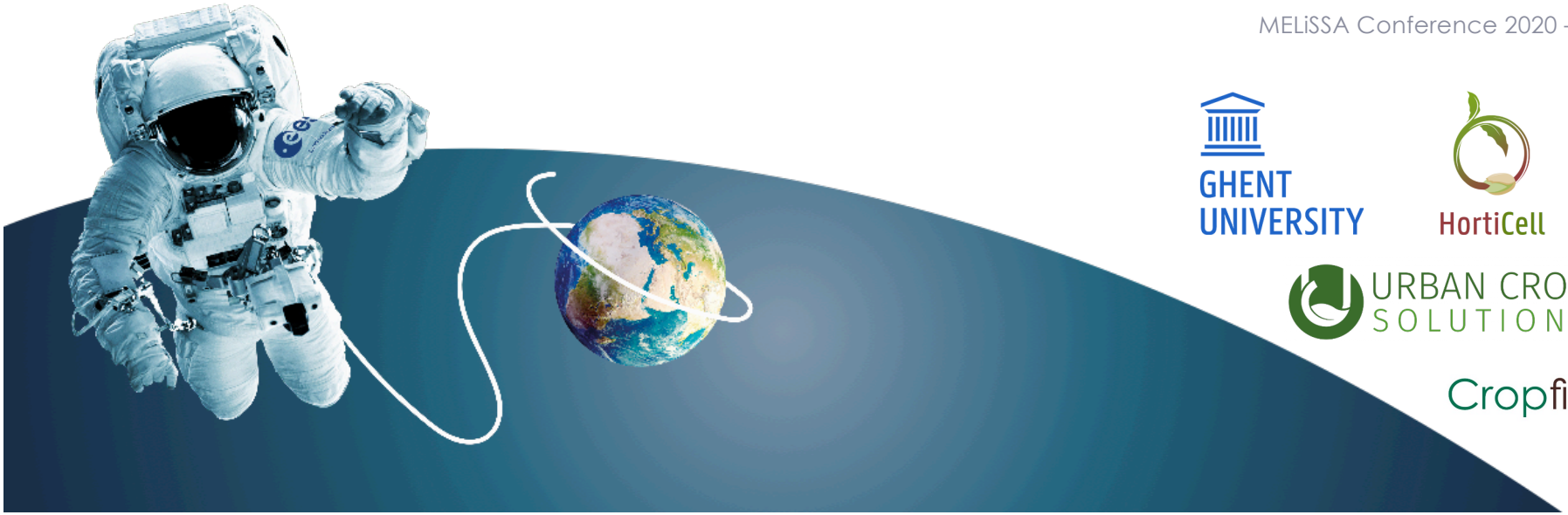
MELiSSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

CREATING A CIRCULAR FUTURE

Microbes in Hydroponic Crop Cultivation in Space

Danny Geelen

MELiSSA Conference 2020 – November 3-5



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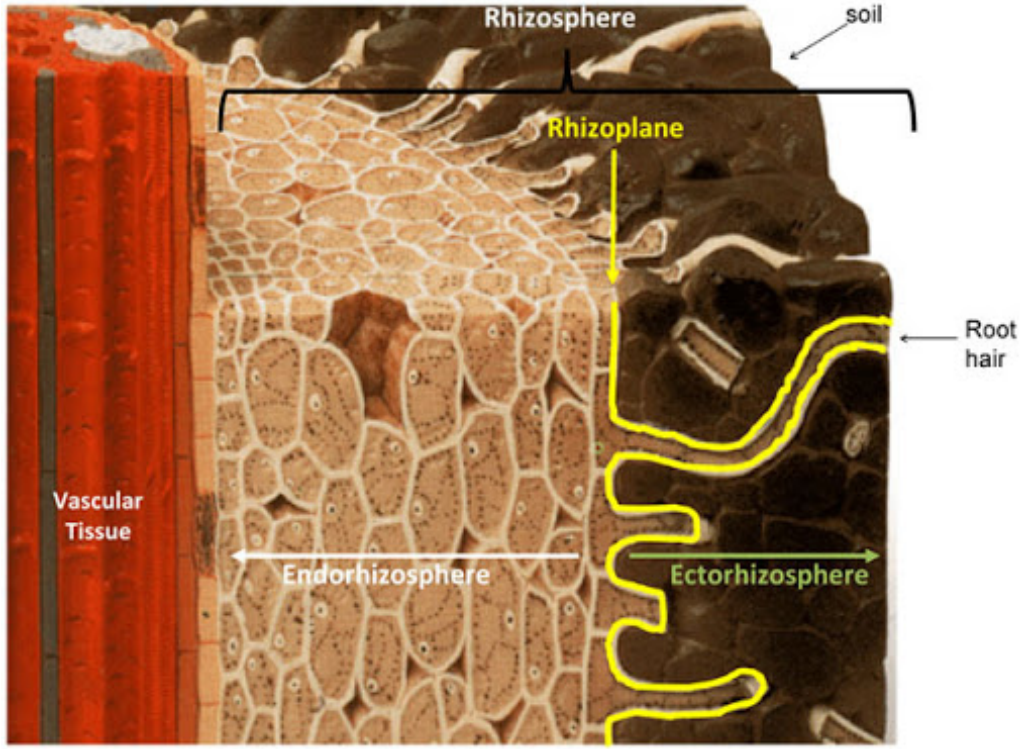
Rhizosphere microbiology

- Plants secrete organic molecules (exudate) to control microbial growth in its surroundings.
- The rhizosphere microbiome consists of a complex mixture of bacteria and fungi that consume the plant's exudate, preventing pathogens to attack the plant.
- The soil composition and physical properties affects the microbiome.



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How do plant-microbe-soil relate to each other?

The use of urine derived organic fertilizer in hydroponic cultivation

Test the impact of urine derived products on lettuce growth and microbiome composition.

Plant: lettuce
Soil: rockwooll blocks
Microbes: from rain water

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Urine derived organic fertilizers

URINE FERTILIZER	Liquid /solid	Preparation	main N compound
Stabilized urine – low pH	Liquid	Stabilized real human urine at pH 2 after HCl addition	urea
Stabilized urine – high pH	Liquid	Stabilized real human urine at pH>11 after NaOH and CaO addition	urea
Hydrolyzed urine	Liquid	Stored real human urine (after spontaneous urea hydrolysis)	TAN (ammonia and ammonium)
ED concentrate	Liquid	Real human urine treated with precipitation, nitrification & electrodialysis	nitrate
Aurin	Liquid	Commercial fertilizer made from real human urine, using partial nitrification and distillation	ammonium nitrate
K-struvite	Solid		ammonium
Urine precipitate – NaOH	Solid	Precipitate obtained by increasing the pH of fresh urine to 12.5 with NaOH	?
Urine precipitate – CaO	Solid	Precipitate obtained by increasing the pH of fresh urine to 12.6 with CaO	?

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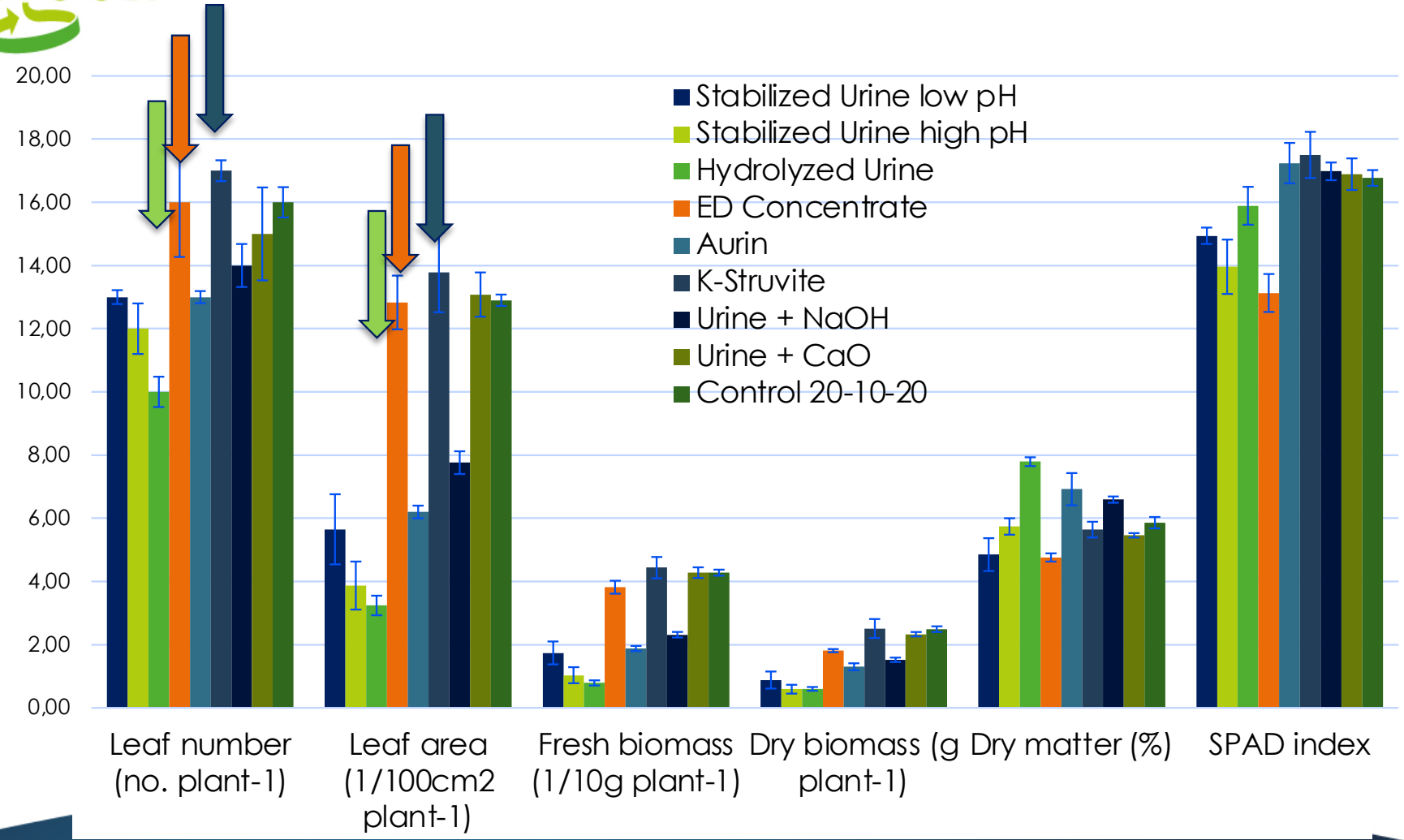
Impact of urine fertilizer on lettuce growth



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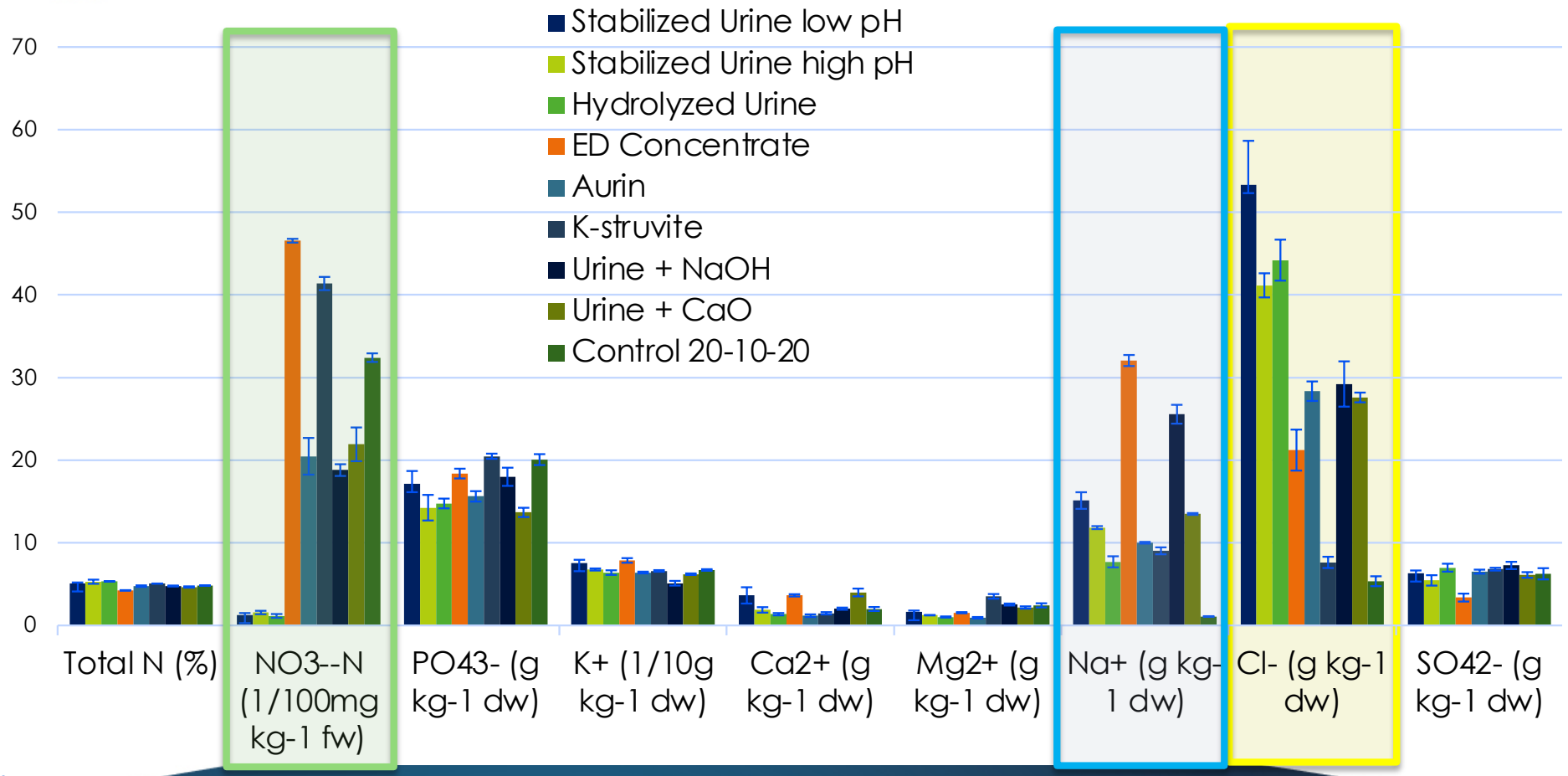
Impact of urine fertilizer on lettuce content



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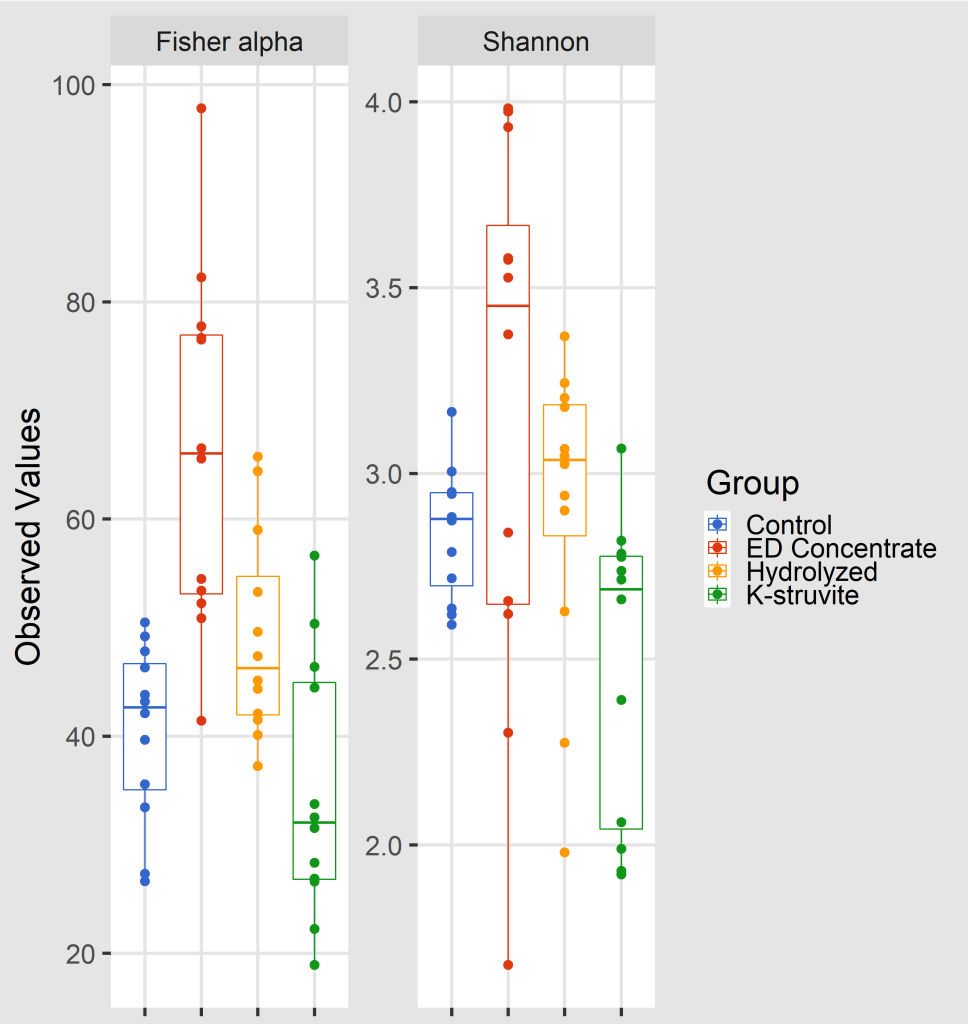
Microbiome analysis methodology

- Lettuce was grown using ED concentrate, K-struvite and poor performing Hydrolyzed Urine and compared to NPK 20-10-20.
- Samples were taken from nutrient solution, rhizosphere, rhizoplane and endorhizosphere.
- DNA was extracted and 16S PCR amplicons sequenced.
- Biodiversity was analysed using Fisher and Shannon indices.
- Differential abundance was analysed by DESEQ2 Wald test.
- Microbial networks were analysed by SpiecEasi R package.

Microbial biodiversity across the treatments



Overall, the microbial diversity is quite similar. Control and K-struvite are the least complex.

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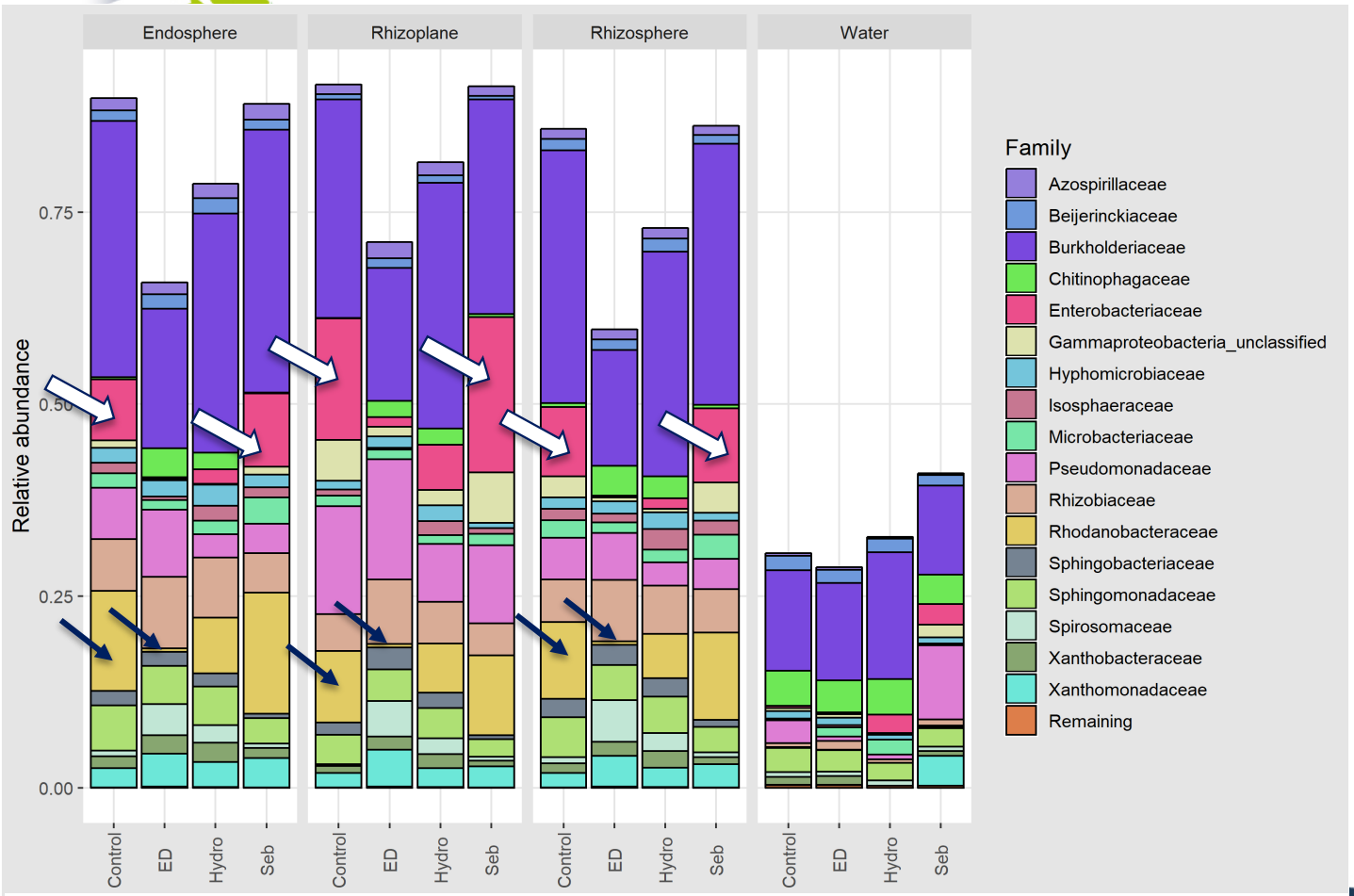
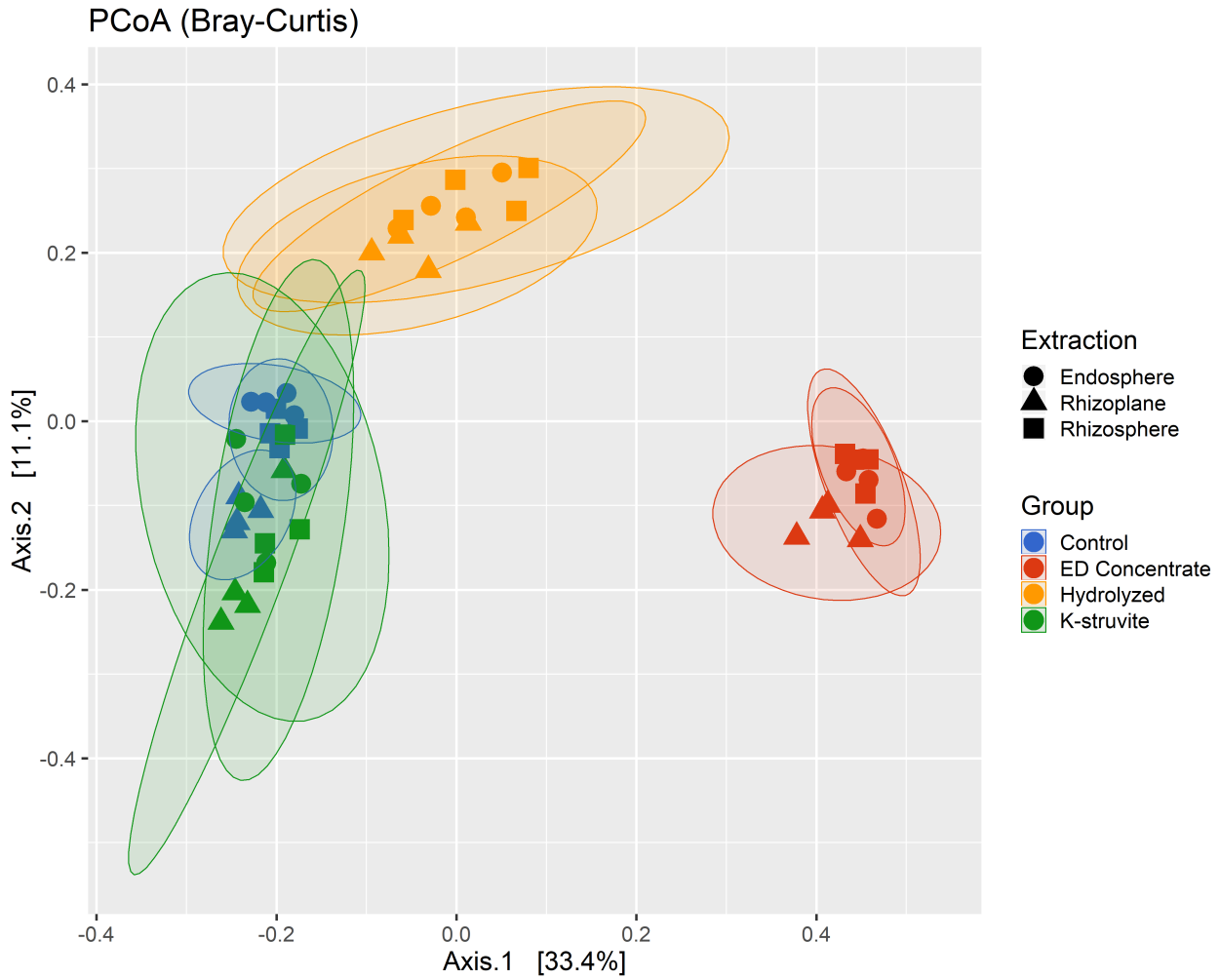
Taxonomy of samples



Relative abundance of bacterial families that are present at an abundance >1%.

- The nutrient solution microbiome is separate from the other samples.
- The treatment with organic fertilizer has a profound impact on the microbiome at all positions: the rhizosphere, the rhizoplane and the endorhizosphere .

Beta-diversity across the treatments



K-struvite and NPK20-10-20 show strong overlap in microbial taxa. ED Concentrate contains the most different microbiome.

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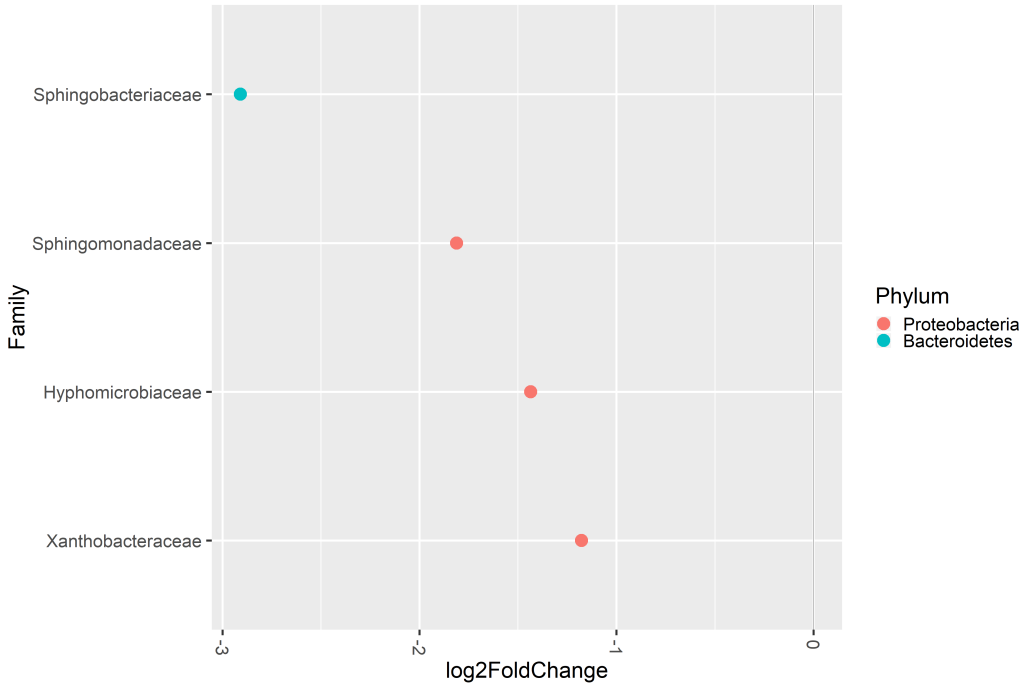
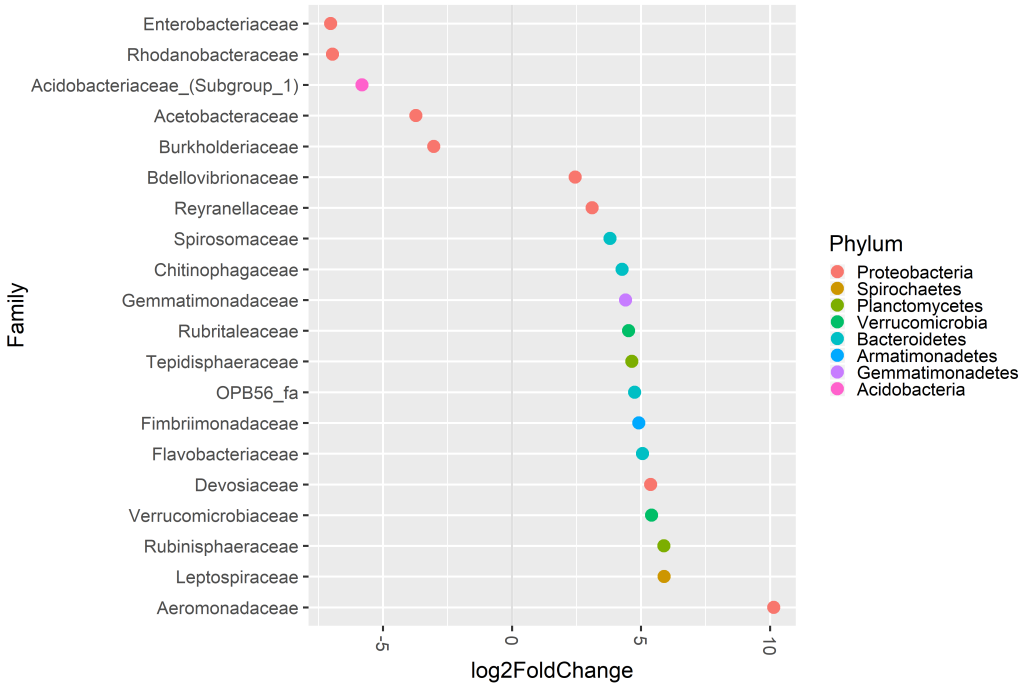
Treatment – taxa correlations

Differential Abundance Between K-Struvite and Control

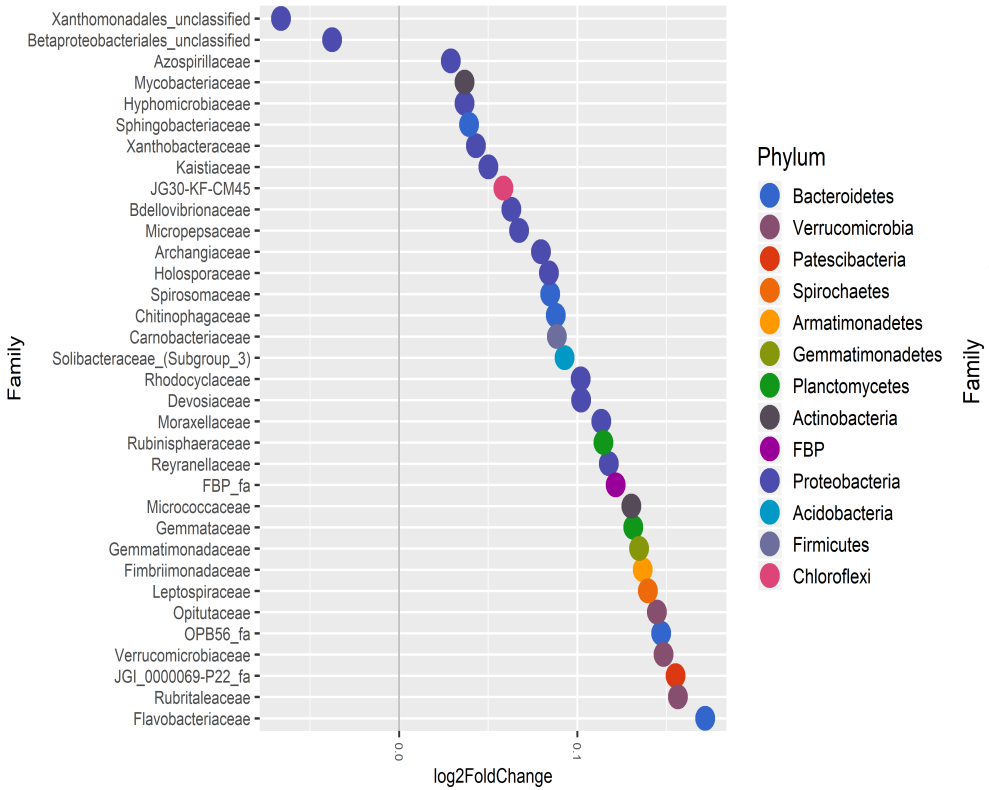


Differential Abundance Between ED Concentrate and Control

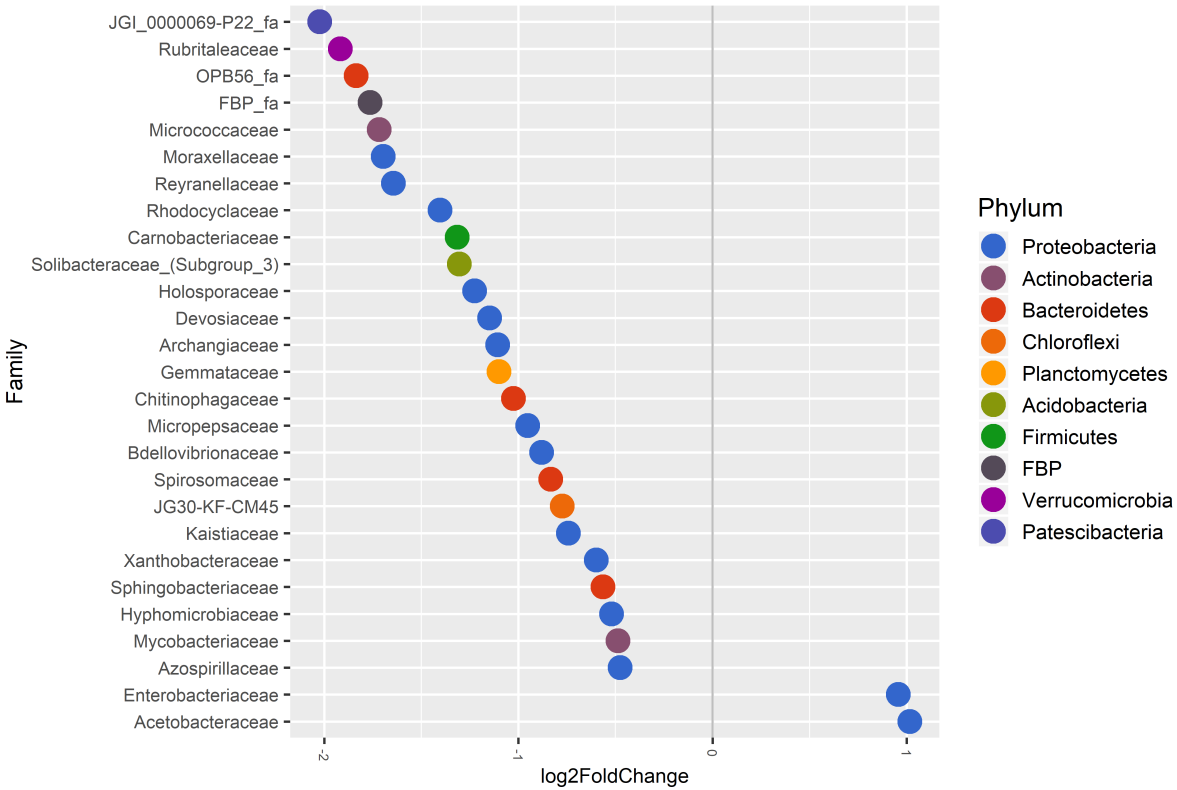


Plant data – taxa correlations

Microbes Associated with Chlorine Accumulation



Microbes Associated with Lettuce Dry Weight



Conclusions

- Hydroponic lettuce production and quality is under strong influence of the type of urine derived fertilizer.
- Different urine fertilizers drive distinct rhizo-community composition
- NPK 20-10-20 and the K-struvite, the two highest yielding nutrient solution preparations, grew plants with very similar rhizo-communities.
- Hydroponic systems harbor diverse microbial communities to be exploited for protection against human and plant pathogens

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