Harnessing the complex microbiota of aquaponic systems for plant growth promotion

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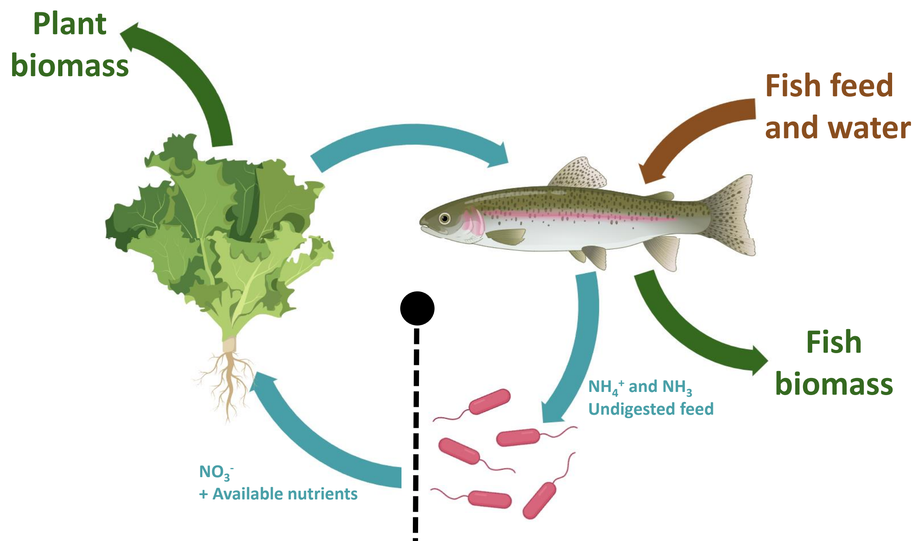
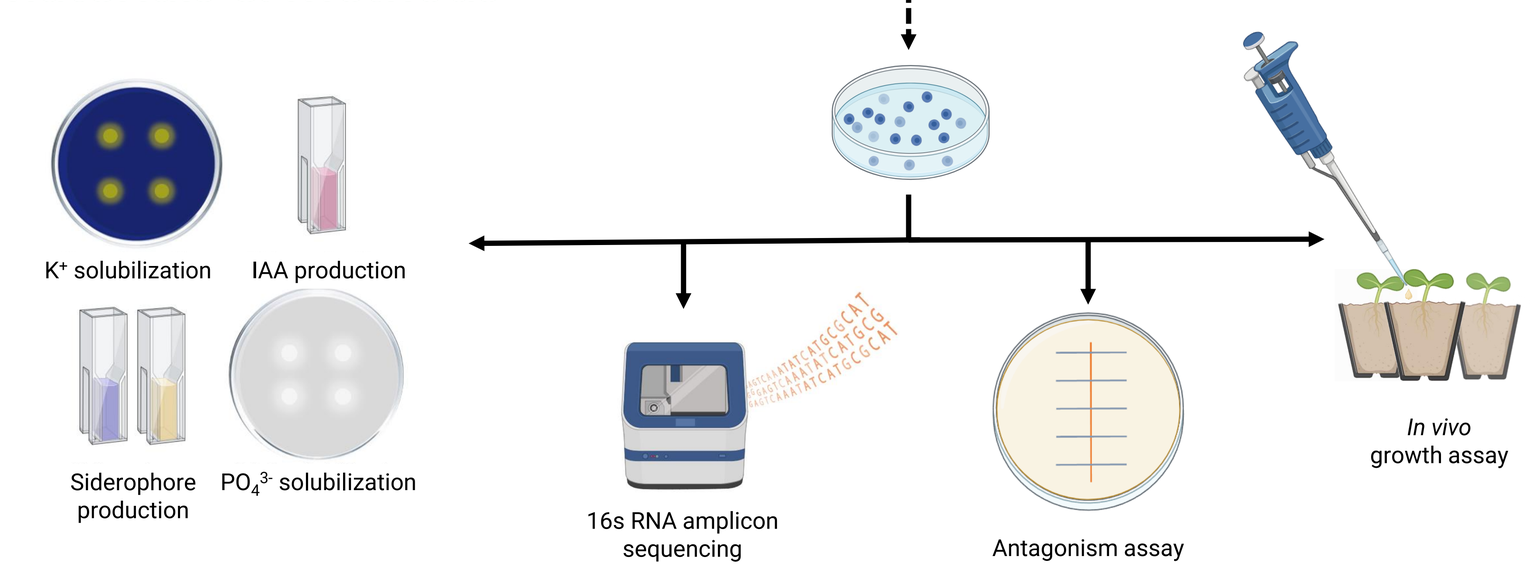
Context

Aquaponics is a **soilless food production system** that sustainably yields plant and fish biomass in a closed loop[1]. It is based on water and nutrient flow and beneficial interactions between **fish, bacteria, and plants**. Controlling the nutrient flow that gets to the growing crops can, however, be difficult, as the only input are the water and the fish feed[2]. This leads to a significant problem: only a **few available mineralized nutrients** reach the plants. This problem is exacerbated when rearing trouts in the fish compartment. Trouts are freshwater fish: they require a clean water. To ensure an optimal growth environment, water must be frequently renewed, making nutrient accumulation impossible.

Previous studies have highlighted the existence of a complex microbial network[3] and the presence of potential plant growth-promoting (PGP) bacteria within aquaponic systems. Nutrient cycling, and thus crop yield, in aquaponics could be improved by harnessing such diversity by designing a PGP bacterial consortium, especially in a trout-rearing situation.



Materials & Methods



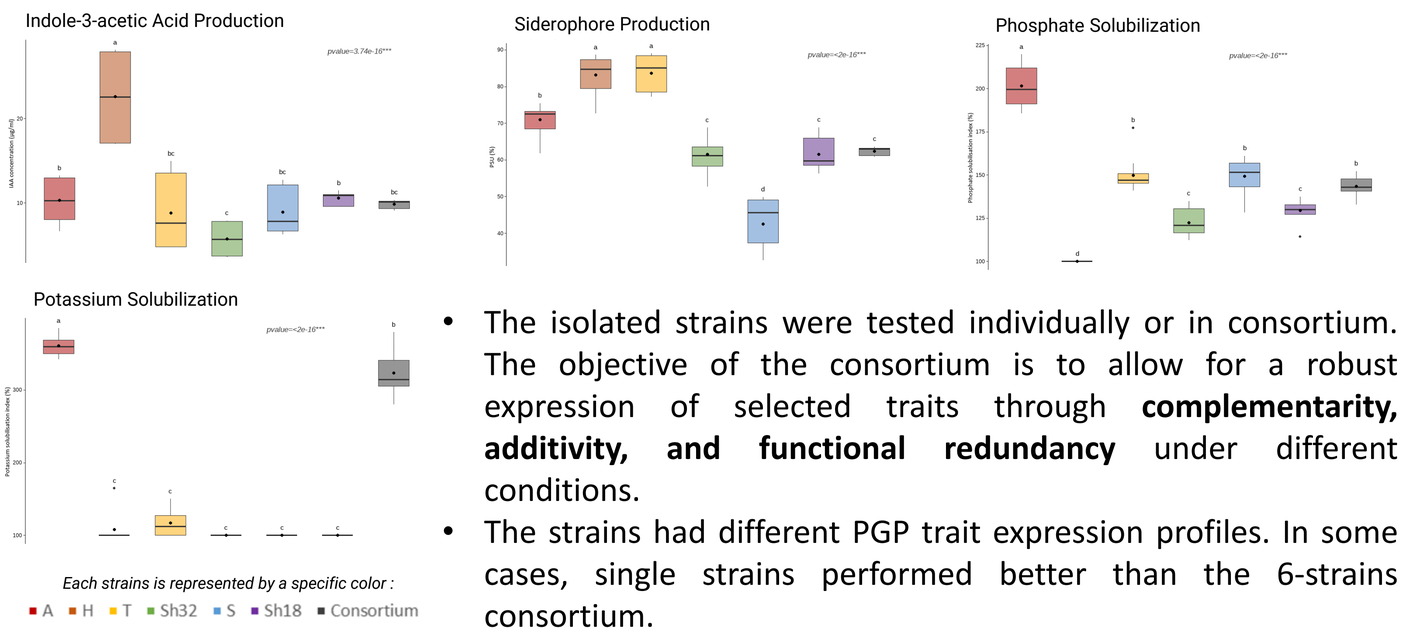
Strains were **isolated from the aquaponic sump and lettuce rhizoplane** and characterized *in vitro* :

- What are their functional traits?
- Can they co-exist and work together?
- Do they promote plant growth in aquaponic settings ?

A total of 6 strains were selected for *in vivo* testing

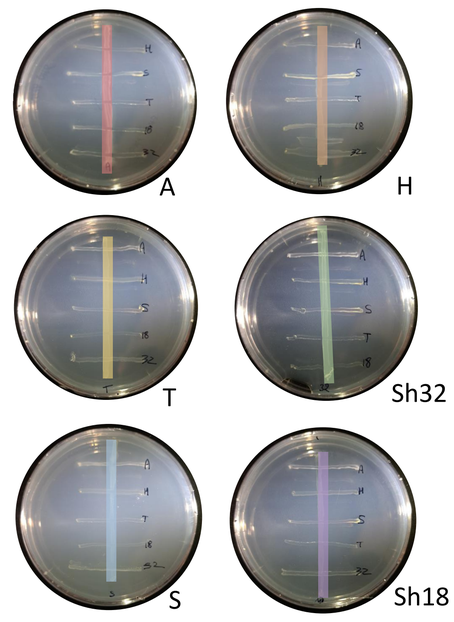
- In vivo trials were performed on **small-scale aquaponic raft systems** under controlled conditions. Lettuce seedlings were treated at cotyledon and first true leaf stages. Effect on plant growth was quantified 5 weeks after sowing.

Strains PGP traits : *in vitro* evaluation



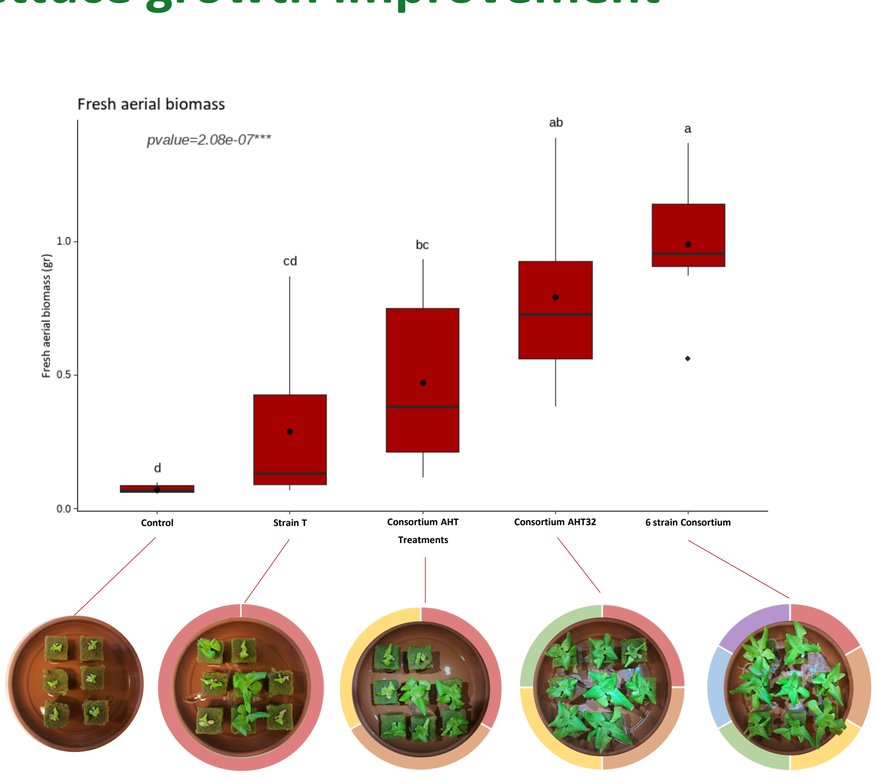
- The isolated strains were tested individually or in consortium. The objective of the consortium is to allow for a robust expression of selected traits through **complementarity, additivity, and functional redundancy** under different conditions.
- The strains had different PGP trait expression profiles. In some cases, single strains performed better than the 6-strains consortium.

Antagonism assessment



- Assays were performed on gelified aquaponic water.
- No antagonistic interactions were found between the selected strains, neither by antibiosis nor spatial competition.
- All strains can develop next to each other and were all considered for a six-strain consortium.

Lettuce growth improvement



- **Treatments significantly improved various growth parameters** : biomass (root and shoot, fresh and dry), number of leaves, and longest leave length.
- We observed a significant increase in plant growth parameters with the complexity of the consortium (determined by the number of strains, all added in equal proportions at 10^8 cells/ml).
- The addition of a single strain to a lesser complex consortium can have a drastic impact on plant growth.

Conclusions & prospects

The encouraging results obtained in this study highlight the hidden potential in the microbial communities of aquaponic systems. Further studies are, however, needed to confirm consortium effectiveness (large scale, complete growth cycle, effect on fish, etc.) and to deepen our understanding of the consortium (existence of synergy, the treatment effect on native microbiota, etc.)

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Bibliography

[1]Goddek S, Delaide B, Mankasingh U, Ragnarsdottir KV, Jijakli H, Thorarinsdottir R. Challenges of Sustainable and Commercial Aquaponics. Sustainability. 2015; 7(4):4199-4224. https://doi.org/10.3390/su7044192
[2]Eck, M., Körner, O., Jijakli, M.H. (2019). Nutrient Cycling in Aquaponics Systems. In: Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (eds) Aquaponics Food Production Systems. Springer, Cham. https://doi.org/10.1007/978-3-030-15943-6_9; [3]Eck M, Sare AR, Massart S, Schmautz Z, Junge R, Smits THM, Jijakli MH. Exploring Bacterial Communities in Aquaponic Systems. Water. 2019; 11(2):260. https://doi.org/10.3390/w11020260