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Mechanistic *vs* **Realistic**: an impossible Love Story in the root system ecophysiology world?

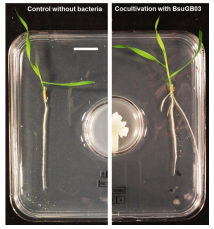
Dr Pierre DELAPLACE

- Plant Sciences -

ULB – March 14th 2023

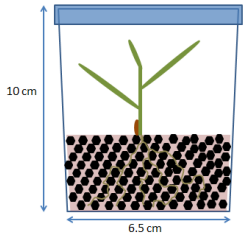
It all started in… 2010

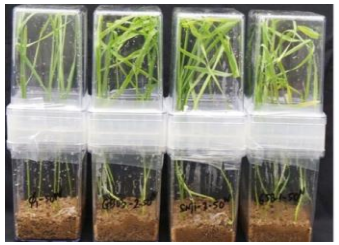
- Developing expertise in root ecophysiology
- Building projects based on scientific hypotheses to be tested with relevant tools
- Nice timeline of experiments with an ‘end user’ point of view



Racine dense

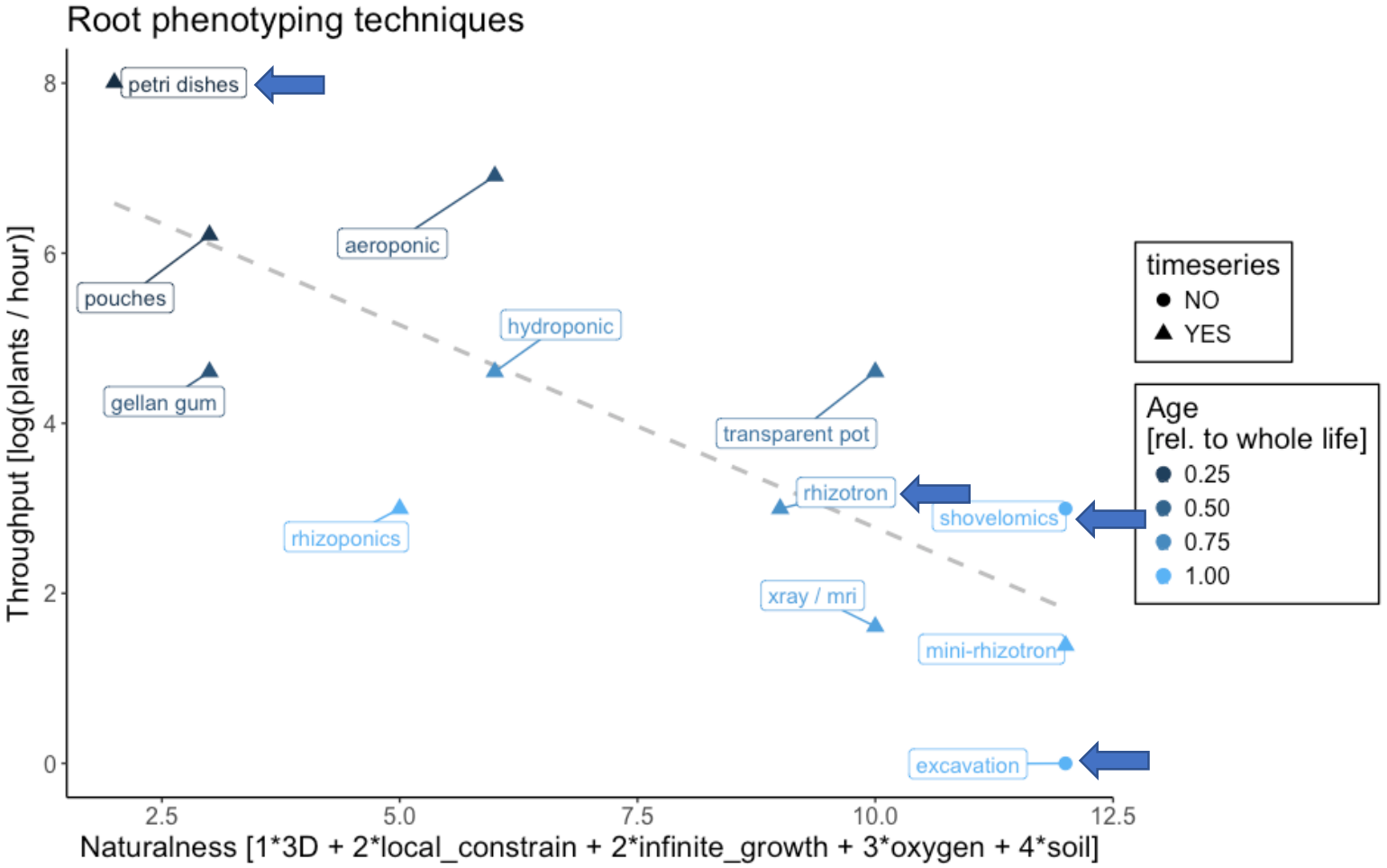
2010 2012 2014 2019 2020 2022 2023





Experimental setups

Usually a trade-off between the “naturalness” of the growing setup and its throughput



Lobet, G. (2017). Root phenotyping platforms. figshare.

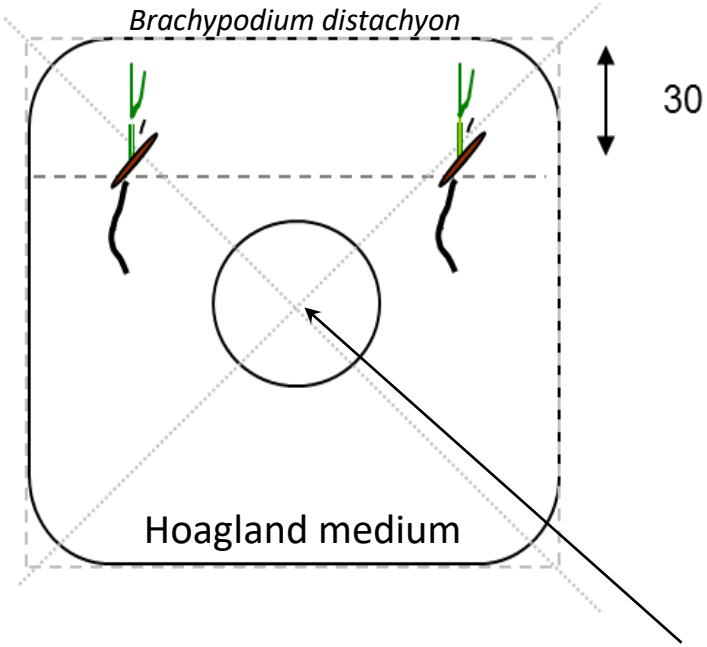
How do Rhizobacterial Volatiles Influence Root System Architecture, Biomass Production and Allocation of the Model Grass *Brachypodium distachyon*?

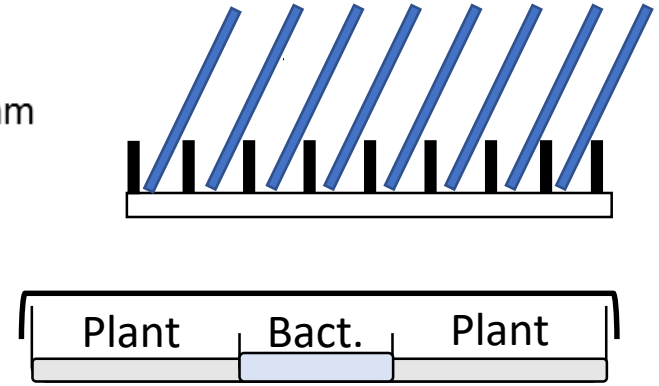
Pierre Delaplace, Elena Ormeño-Lafuente, Minh Luan Nguyen, Benjamin M. Delory, Caroline Baudson, Magdalena Mendaluk-Saunier de Cazenave, Stijn Spaepen, Sébastien Varin, Yves Brostaux, Patrick du Jardin

The main hypotheses:

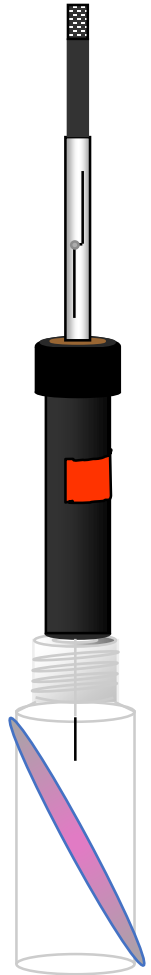
- Bacterial volatiles can promote a model grass growth
- This growth promotion is correlated with significant changes in RSA
- The growth promotion effect is modulated according to the blend of volatiles emitted by the bacteria

The experimental setup:



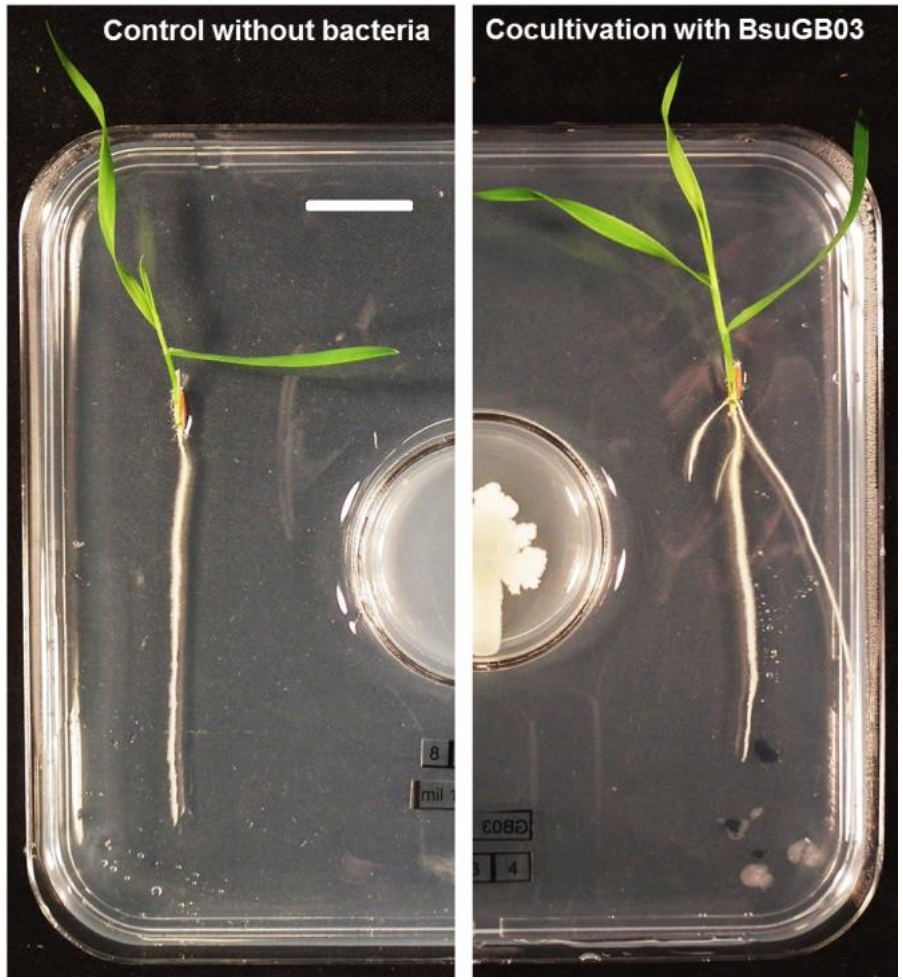


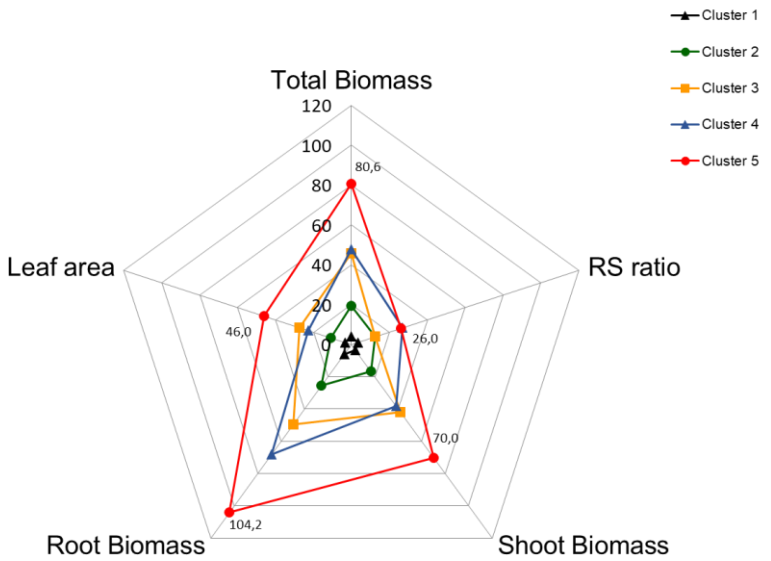
Bacterial compartment
filled with Farag *et al.* (2006) medium

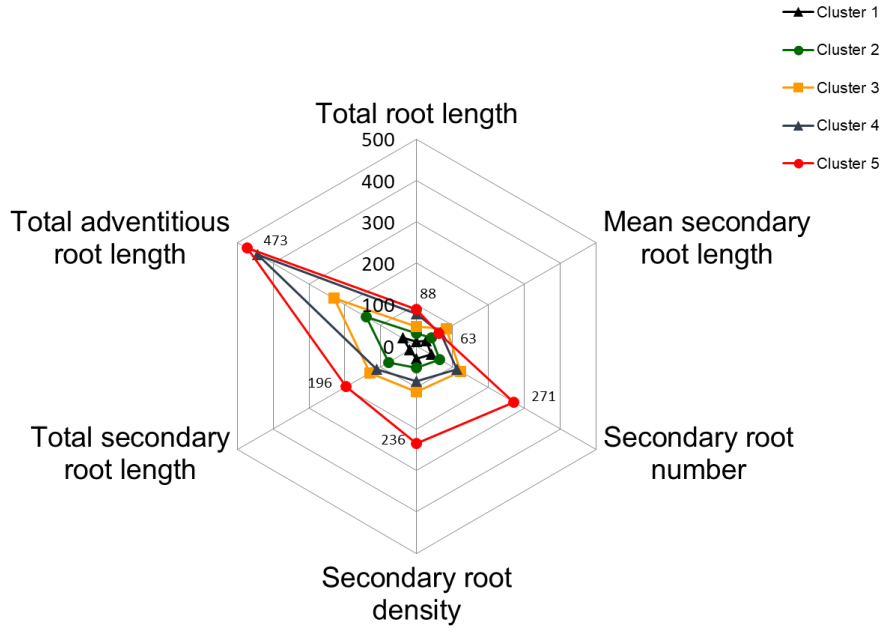


- Surface-sterilization of caryopses
- Vernalization
- Pre-germination
- Cocultivation for 10 days with bacteria in a shared atmosphere

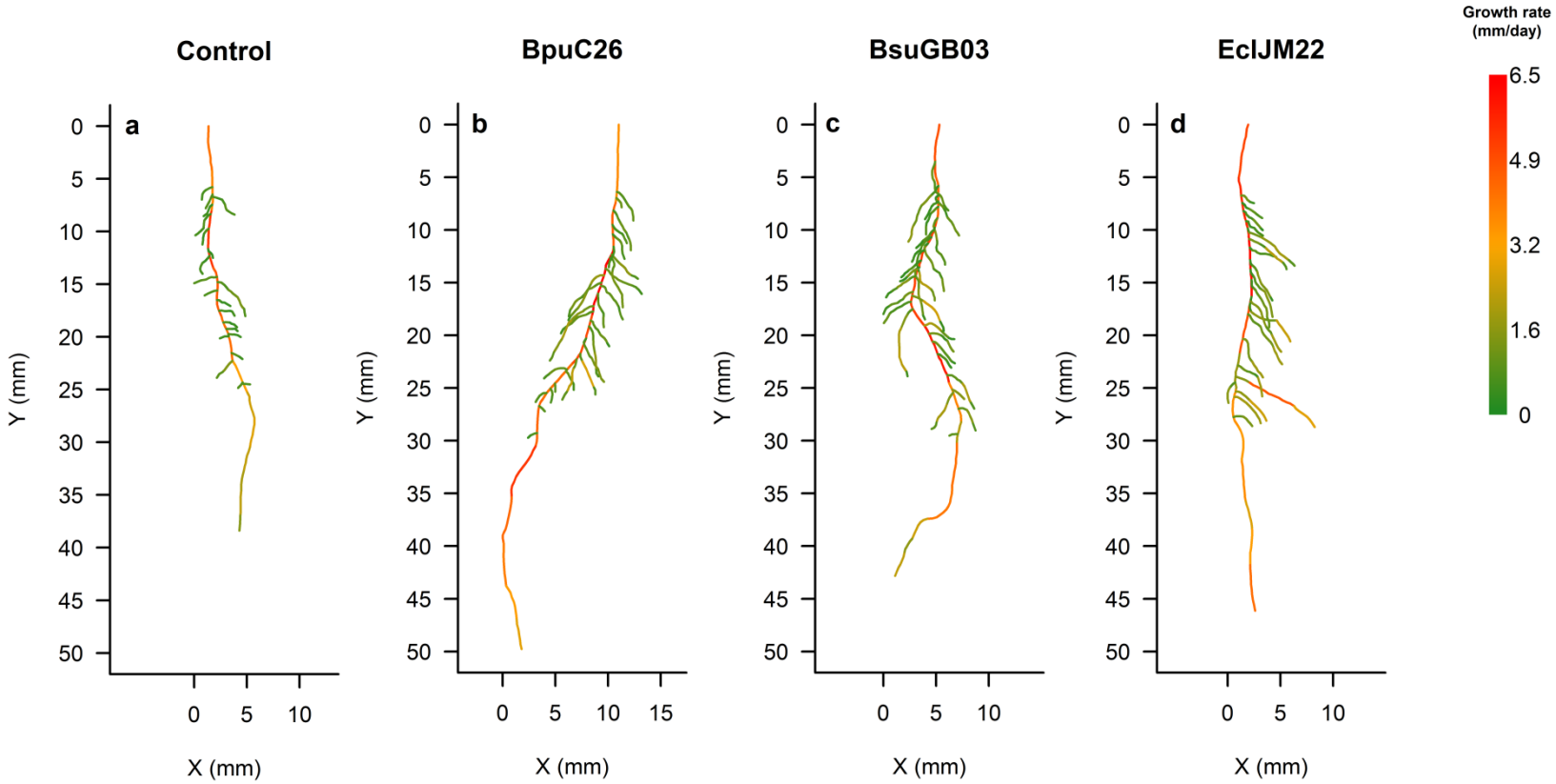
Exemplative results:







Exemplative results:



Were we able to address the questions successfully?

Criteria	Evaluation
Scale for work	Laboratory (Pétri dishes)
Realism level	Poor
Mechanistic level	Very good
Hypothesis testing	Efficient
Transposability to field conditions	Unknown
Throughput / screening ability	High
Timeseries	Yes
Stress application	No, but feasible (how realistic?)
Successful?	Yes

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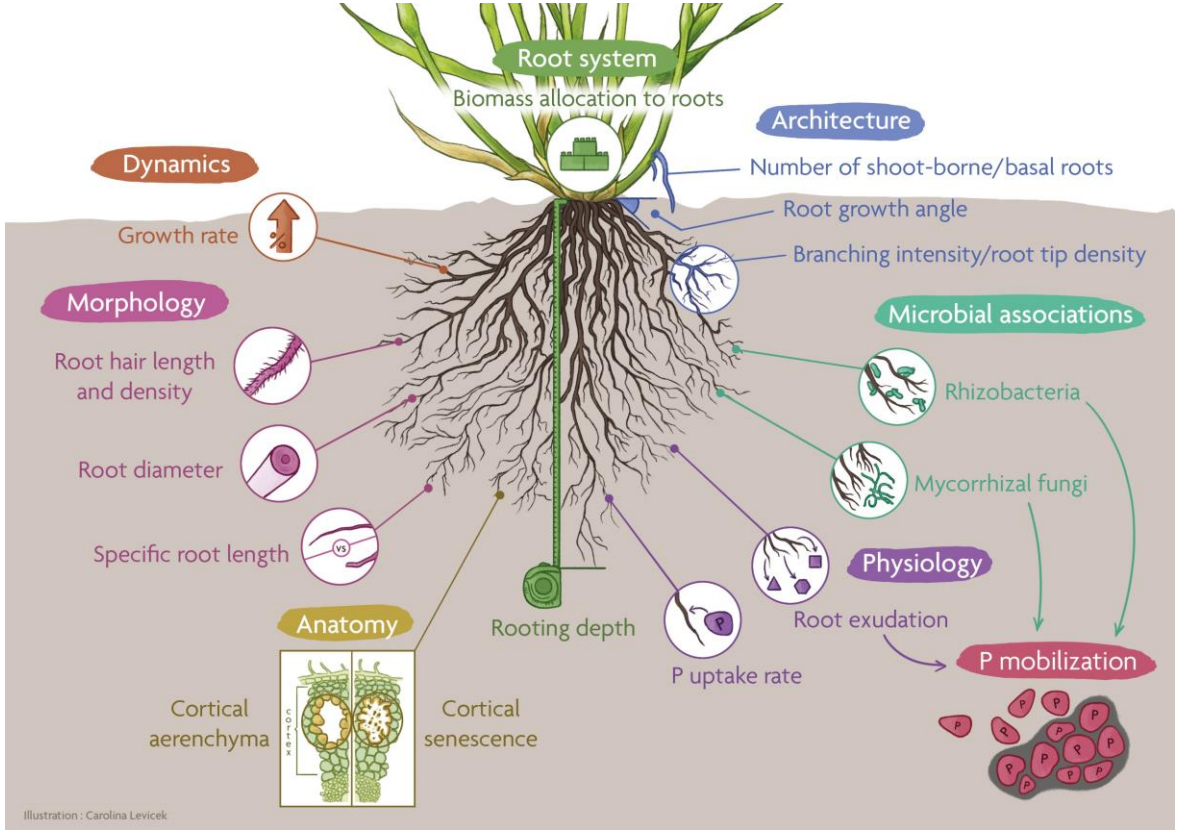
Deciphering the mode of action of biostimulant candidates: a case study on phosphate-solubilizing bacteria

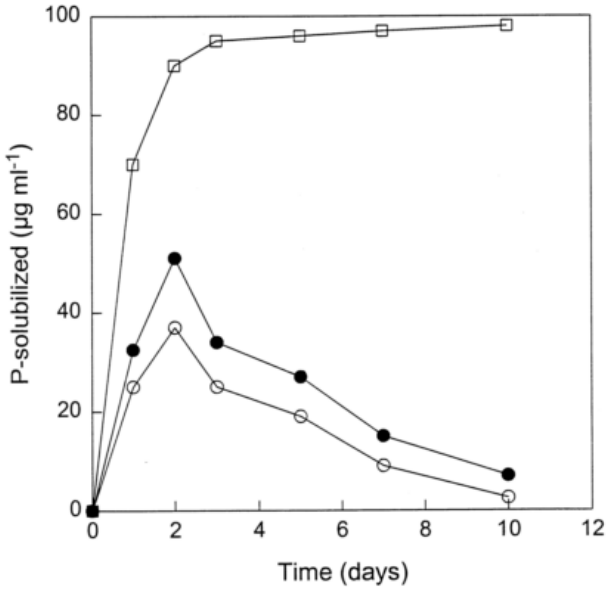
C. BAUDSON, B. DELORY, P. DU JARDIN, P. DELAPLACE



The main hypotheses:

- The selected bacteria are able to solubilize phosphate from lowly bioavailable sources
- The grass plant is not effective alone to mobilize/hydrolize those P sources
- The plant-PSB co-cultivation enhances growth and P uptake under P-limiting conditions if a lowly bioavailable source is present

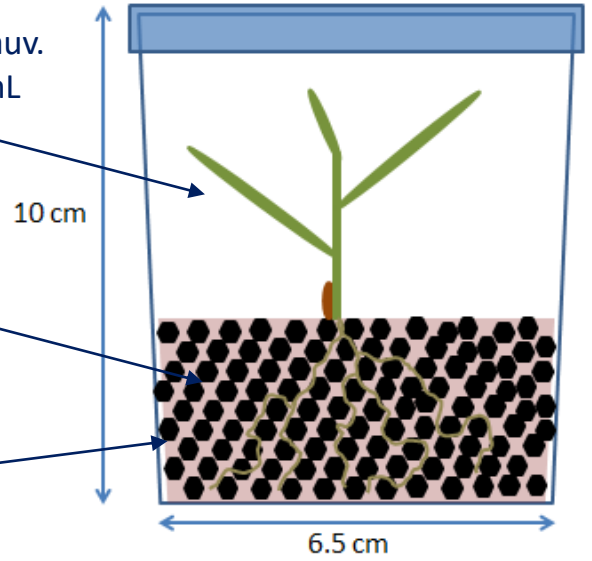
The experimental setup:



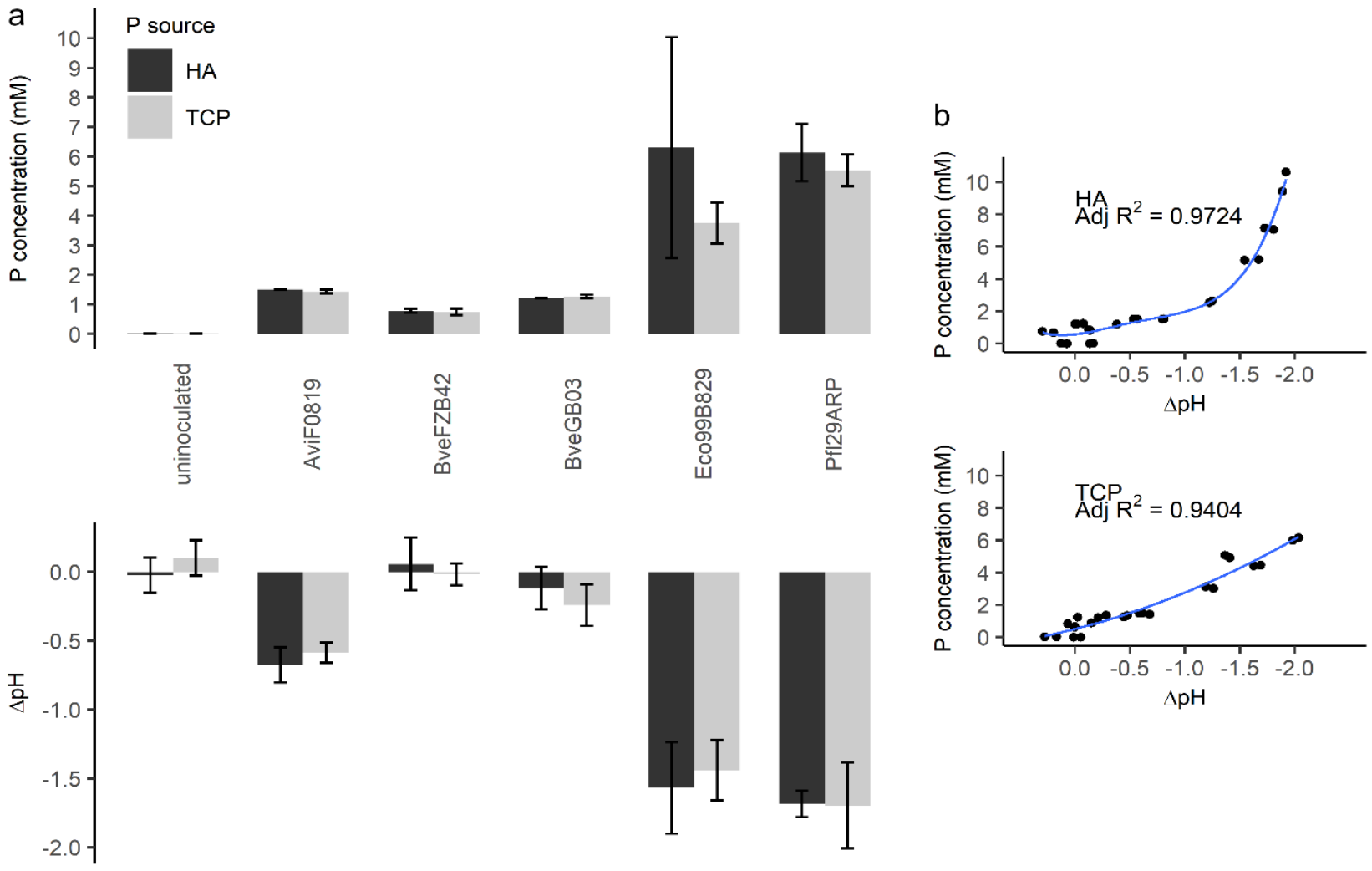
Brachypodium distachyon (L.) P. Beauv.
Plantlet inoculation with 10^8 CFU/mL
Cocultivation during 28 d.

Gravel culture in
Magenta © Boxes

Modified Hoagland solution:
P-, P+, P-/TCP, P-/HA



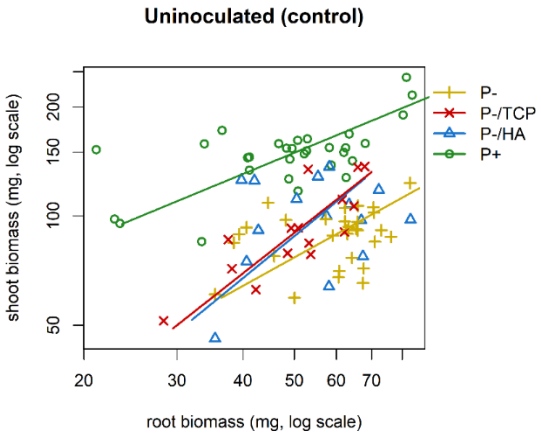
Exemplative results:



Exemplative results:

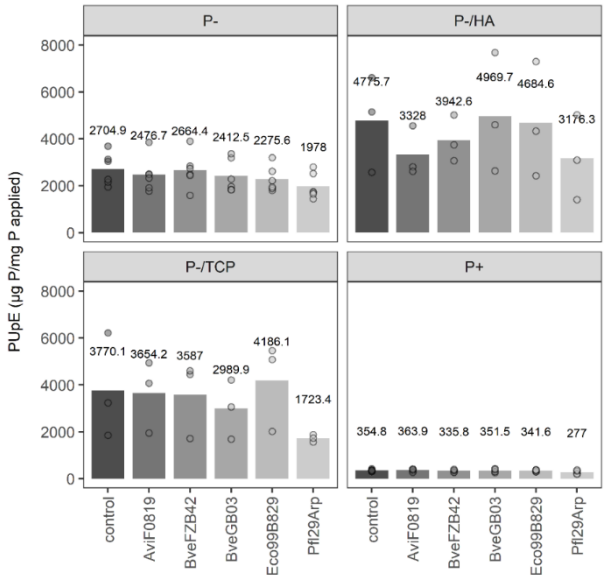
Biomass accumulation

- Conventional approach
- Allometric trajectory analysis



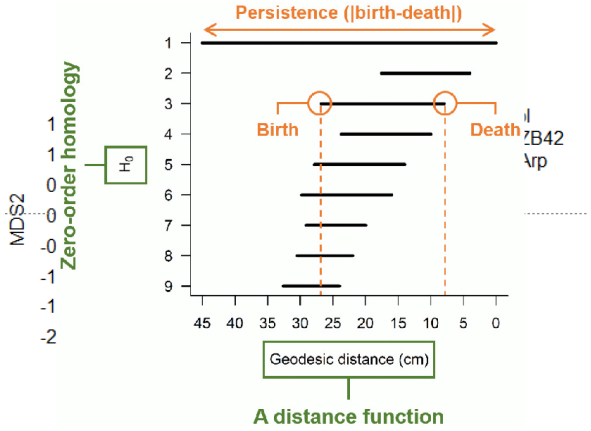
P Use Efficiency

- Shoot P concentration
- P Uptake Efficiency
- P Utilization Efficiency
- Physiological P Use Efficiency



RSA modulation

- RSA integrative parameters
- Global topological analysis



Delory *et al.*, 2018

Were we able to address the questions successfully?

Criteria	Evaluation
Scale for work	Laboratory (Magenta boxes)
Realism level	Poor
Mechanistic level	Theorethically very good
Hypothesis testing	Efficient
Transposability to field conditions	Unknown
Throughput / screening ability	Medium
Timeseries	No
Stress application	Yes, effective
Successful?	No

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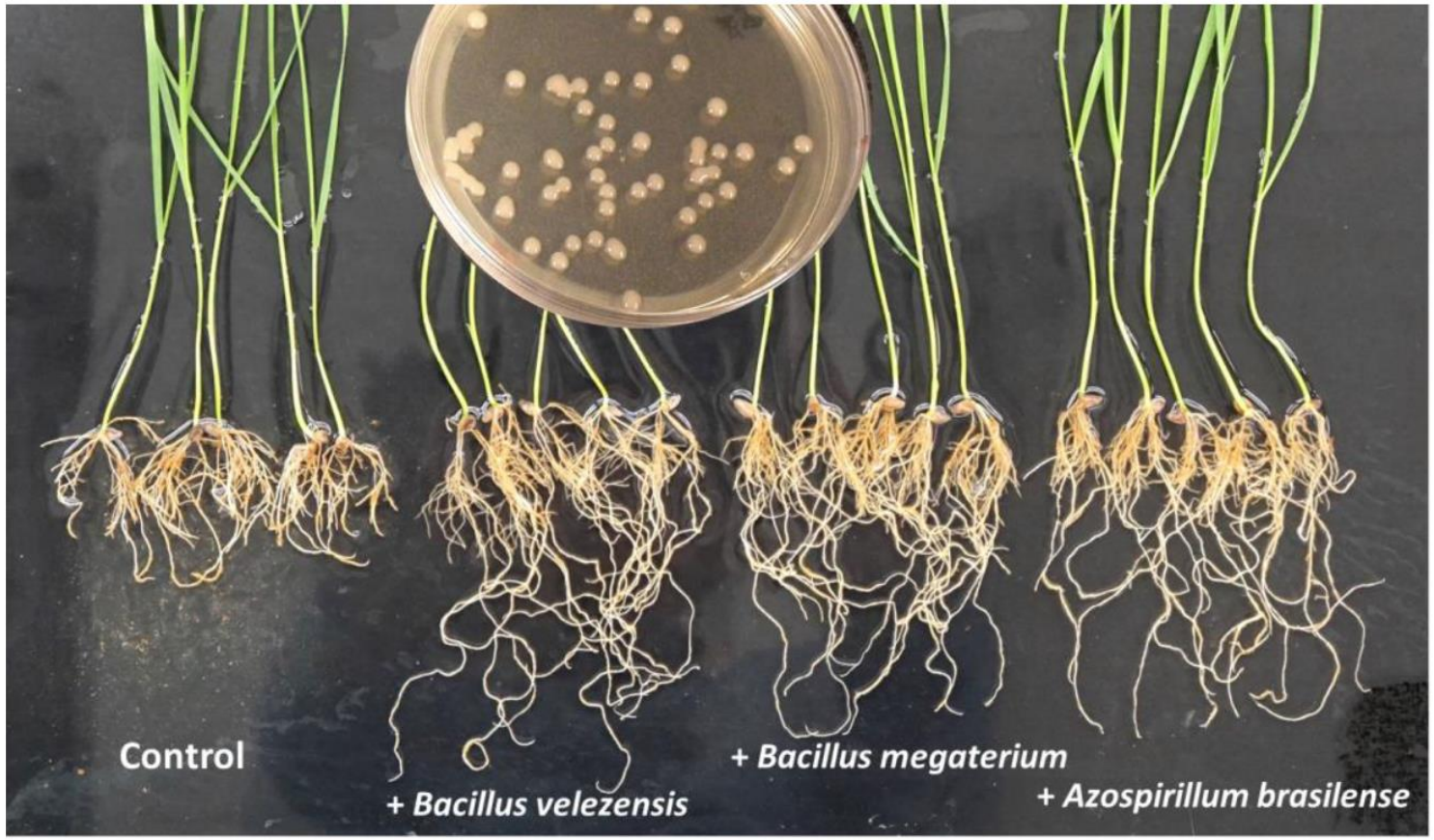
Microbial biostimulation strategy of wheat: impact on growth and nutrient uptake

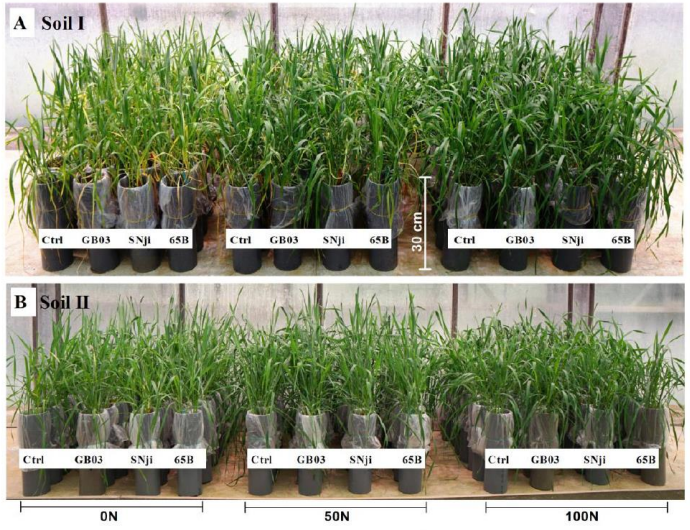
M.-L. NGUYEN, P. DU JARDIN, P. DELAPLACE



The main hypotheses:

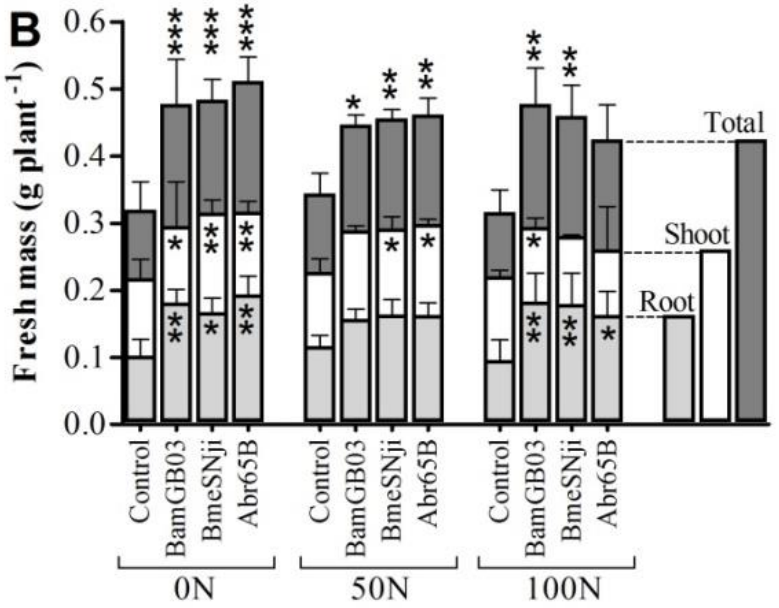
- The selected Free N-fixing bacterial strains promote plant growth under moderate N supply
- The most significant effects should remain as such along the lab-to-field gradient
- The observed effects are not only related to N supply but also root growth modulation

The experimental setup:



Spraying the PGPR-containing products under field conditions

Exemplative results:

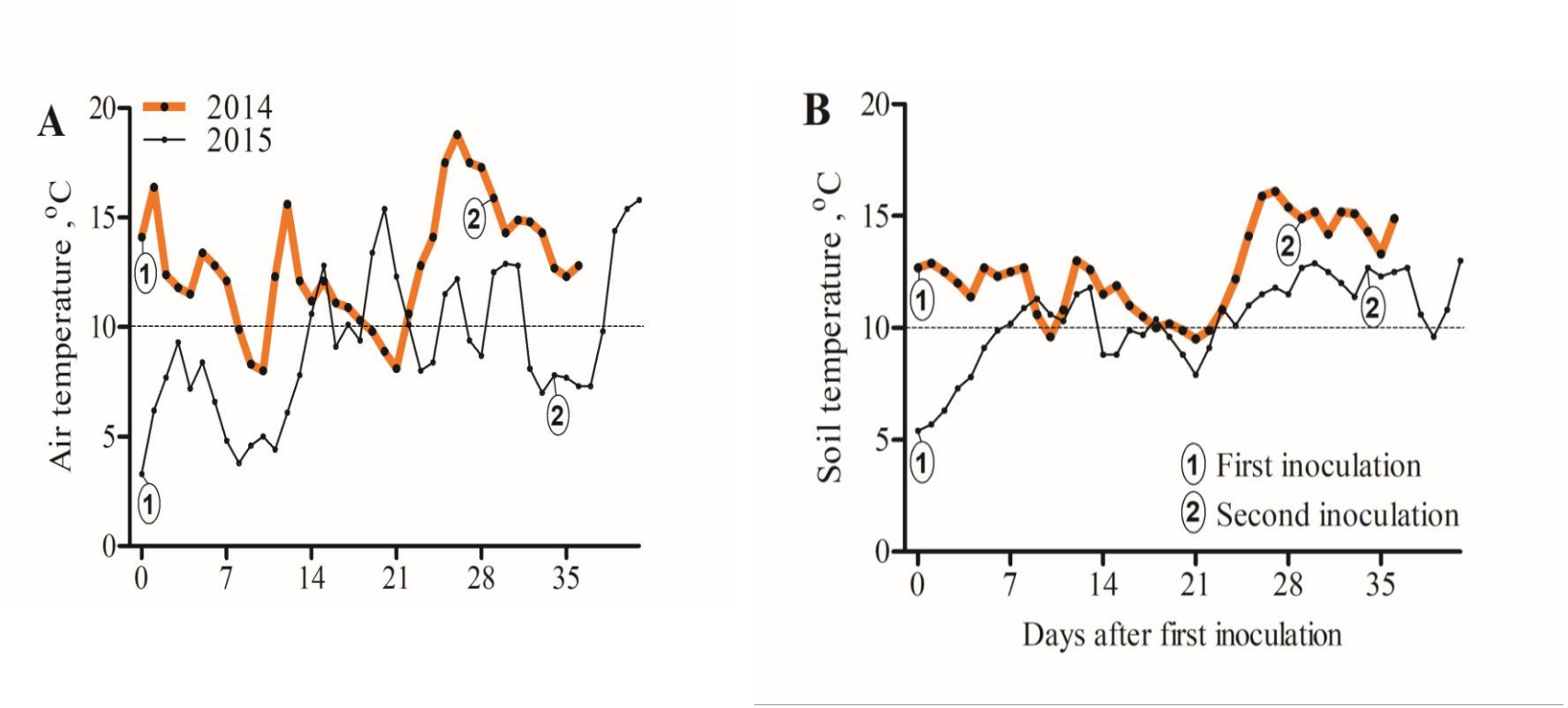


C

PGPR colonization (× 10^7 CFU g^{-1} root and rhizosphere)

Treatments	0N	50N	100N
Control	0	0	0
BamGB03	1.2 ± 0.2	1.0 ± 0.3	2.3 ± 0.4
BmeSNji	1.0 ± 0.2	1.0 ± 0.2	1.6 ± 0.1
Abr65B	3.6 ± 0.7	2.8 ± 0.8	3.0 ± 0.7

Exemplative results:



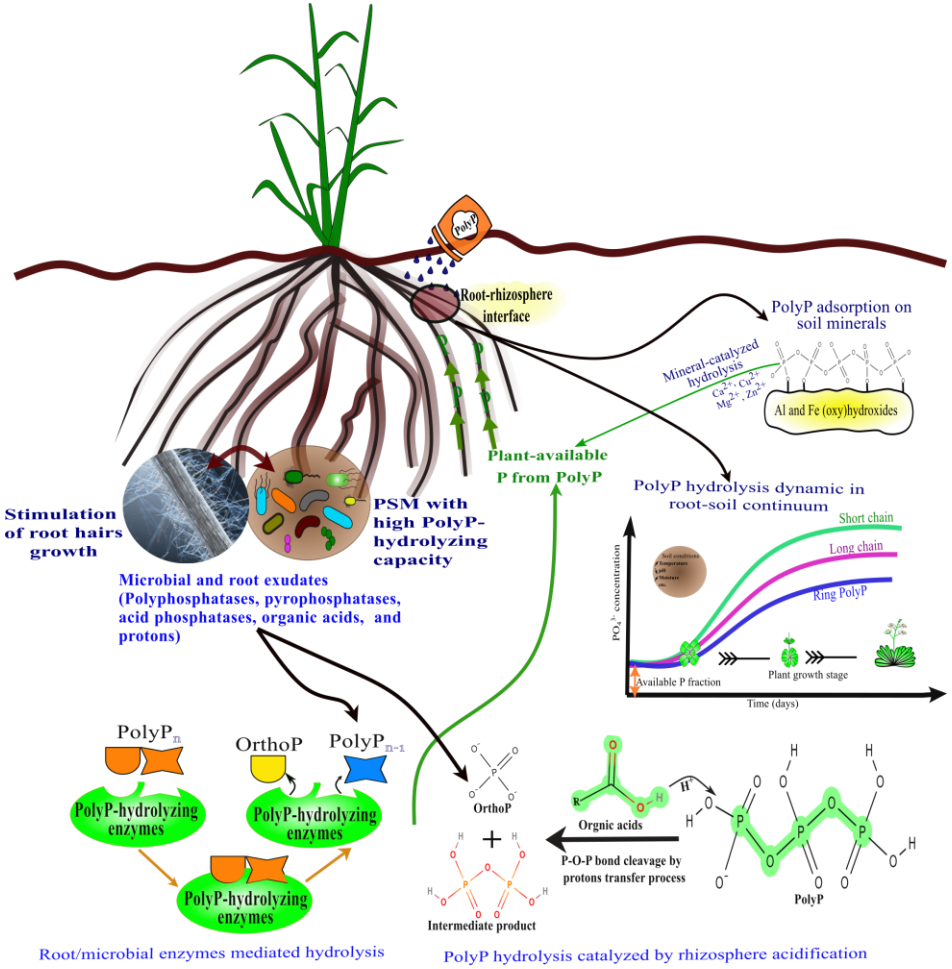
Year	Previous crop	Clay	Silt	Sand	pH KCl	C oragnic total (g $100g^{-1}$)	N-NO3 (mg kg^{-1})	P	K	Mg	Ca
		%						mg $100g^{-1}$			
2014	Oil rape	22	69	9	7.15	1.48	5.86	22.3	29.3	14.5	309
2015	Sugar beet	24	68	8	7.31	1.19	5.58	9.5	17.2	9.3	369

Were we able to address the questions successfully?

Criteria	Evaluation
Scale for work	From lab to the field
Realism level	from poor to fully representative
Mechanistic level	Limited under realistic conditions
Hypothesis testing	Efficient
Transposability to field conditions	Non robust
Throughput / screening ability	Medium
Timeseries	No
Stress application	Yes, effective
Successful?	Only partially

Above and below-ground durum wheat responses to polyphosphate application: Effects on root activities and bacterial phosphate solubilization in the rhizosphere

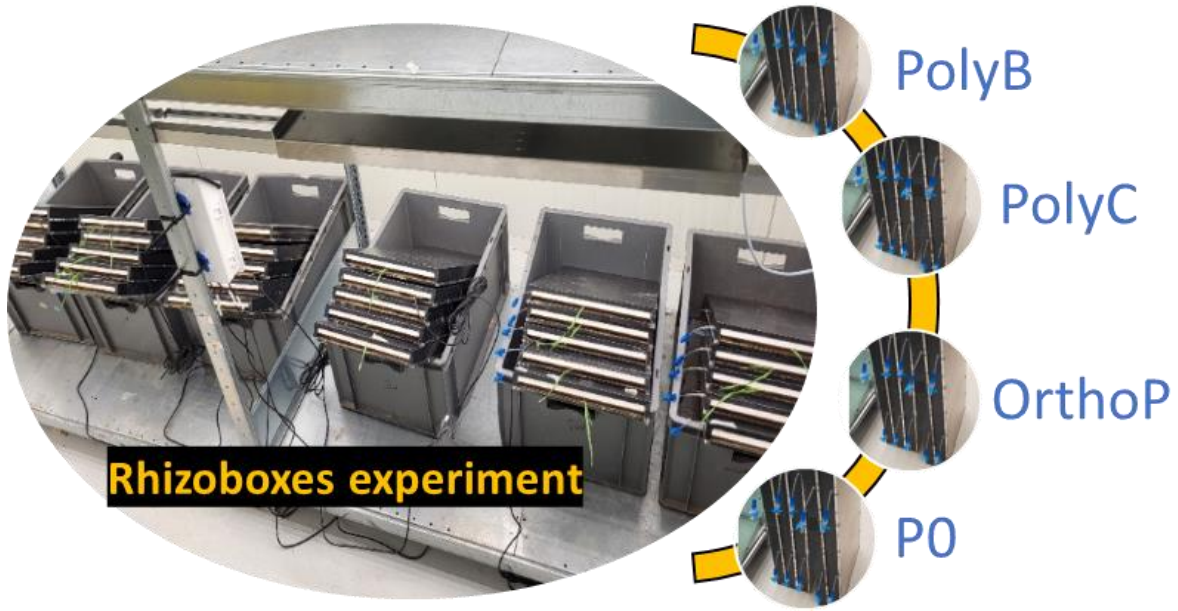
S. KHOURCHI, P. DELAPLACE, A. BARGAZ



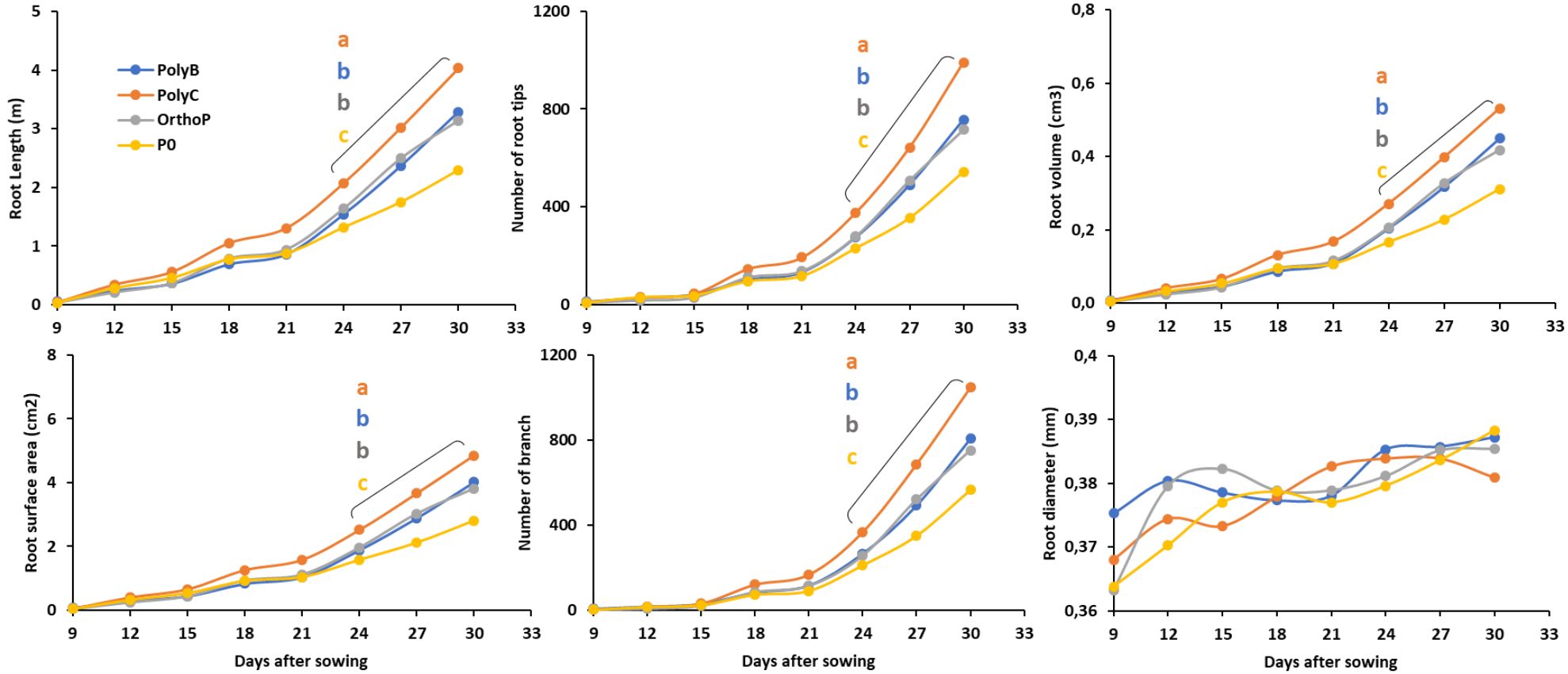
The main hypotheses:

- Polyphosphate Use Efficiency is higher than orthoP under P-limiting (soil) conditions
- This enhanced PolyP UE is related to modulation of RSA and root-associated activities
- Indigenous bacterial strains are rhizocompetent and help mobilize PolyP

The experimental setup:



Exemplative results:

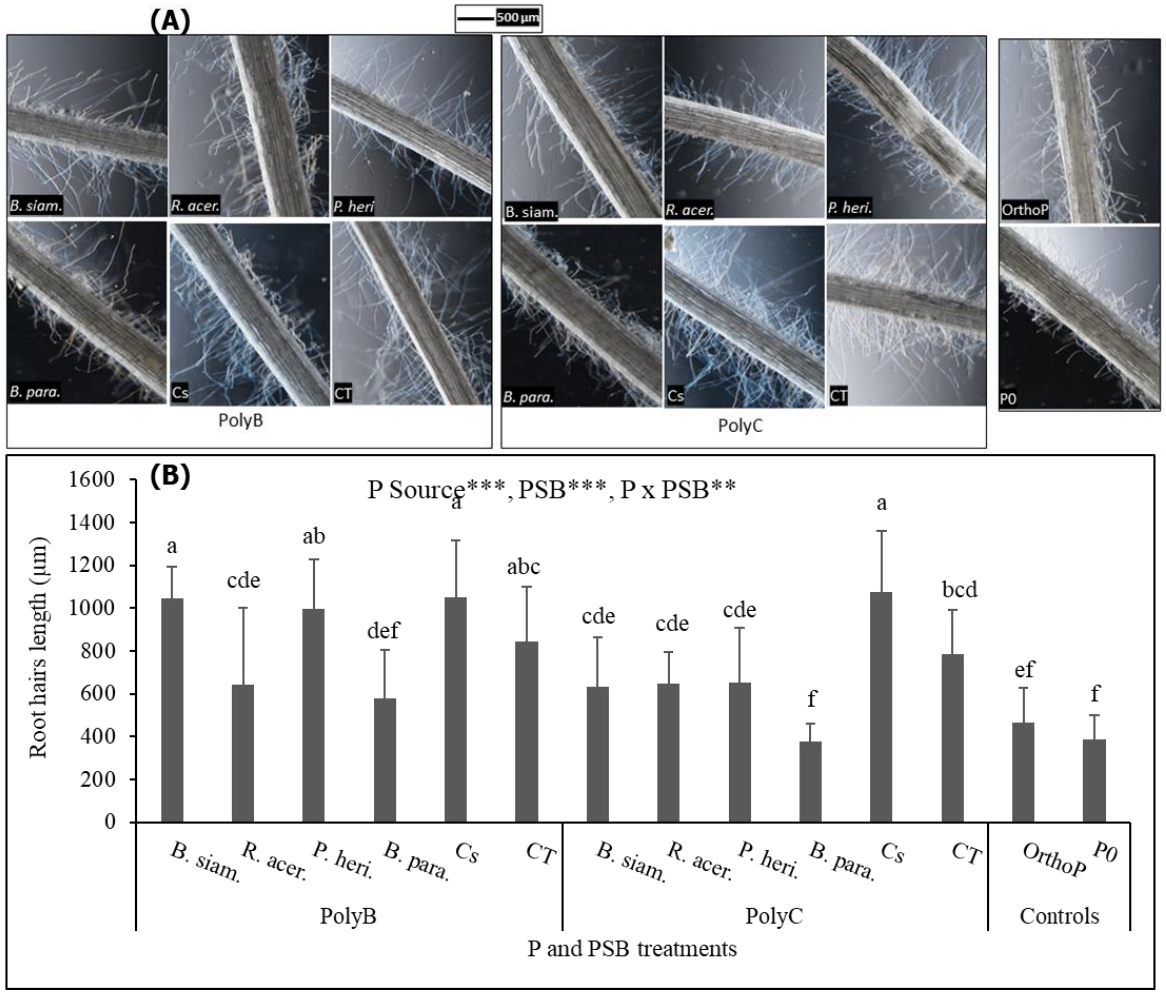


Morphological root traits (root length, root surface area, root diameter and root volume, number of root tips, number of branch) of wheat plants grown in rhizoboxes in response to PolyP (PolyB and PolyC) and OrthoP application.

Exemplative results:

Effects of PolyP-PSB co-application on root hairs growth and elongation of 10-day old durum wheat seedlings in response to inoculation with four P solubilizing bacteria (B. siam, R. acer, P. heri, B. para and their consortium) and PolyP application.

B. siam, *R. acer*, *P. heri*, *B. para* and PSB_{Cs} are *B. siamensis*, *R. aceris*, *P. hericii*, *B. paramycoides* and their consortium and CT represents the uninoculated medium.



Were we able to address the questions successfully?

Criteria	Evaluation
Scale for work	Laboratory gradient (in vitro, soil columns, hydroponics, rhizoboxes)
Realism level	from poor to quite representative
Mechanistic level	Very good
Hypothesis testing	Efficient
Transposability to field conditions	High probability
Throughput / screening ability	Medium
Timeseries	Yes (rhizoboxes)
Stress application	Yes, effective
Successful?	Yes

Conclusions and perspectives

- The lab is not as safe and confortable as it seems
- A realistic soil compartment (composition, nutrient level, temperature, structure, water supply, depth) is key
- Indigeneous vs ‘laboratory rat’ microoragnisms
- Oversimplifying a question leads to non-transposable results to the field
- Compromising / trade-off
- Combining complementary approaches
- Naturalness – Throughput – Mechanistic aspects

What’s next?!

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