The effects of algae fertilizer on wheat root morphology

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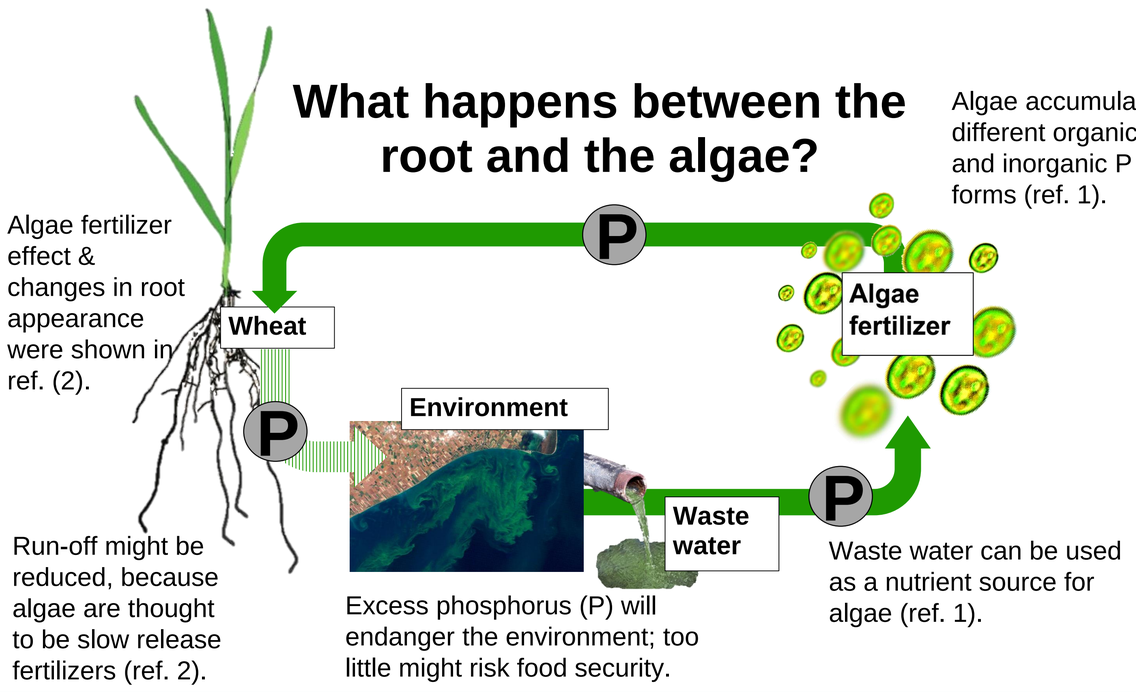
Background- Could algae fertilize wheat to close the phosphorus cycle?

What happens between the root and the algae?



What we want to know…

Goal: The actual P pools, availability and transfer mechanisms to wheat are still unclear - they need to be understood in detail for an optimal use of algae nutrient source.

Hypothesis (1):
Algal phosphorus is available to wheat and is taken up by the root systems directly.

Hypothesis (2):
Differences in root morphology between rock phosphate and algal biomass reflect a change in uptake mode of P.

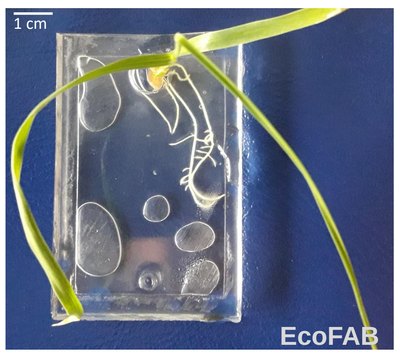
… and how we are planning to figure it out!

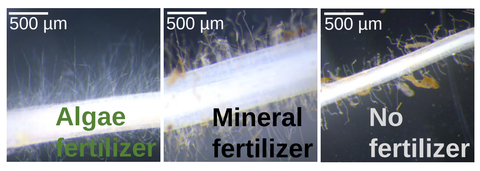
Phenotyping of the root system

Cultivation and analysis of both wheat and *Brachypodium distachyon* in EcoFABs (see box).

EcoFABs (Ref. 3) -
Ecosystem FABrications

- Controlled micro-ecosystems
- Live analysis of roots, microbial interaction and rhizosphere
- Non-destructive, repetitive probing of the rhizosphere
- Reproducibility of the setup
- Highly adaptable





Microscopy pictures of root hairs on wheat roots (ref. 2) in response to different fertilizer regimes (~50 kg/h) or no fertilizer.

Next step: Validation & quantification of changes in root architecture, morphology and, related genetic responses.

Biochemical analysis of phosphorus pools

P-Analytics by e.g. ICP-OES, colorimetric assays etc. in algae, the rhizosphere/medium and the plant.

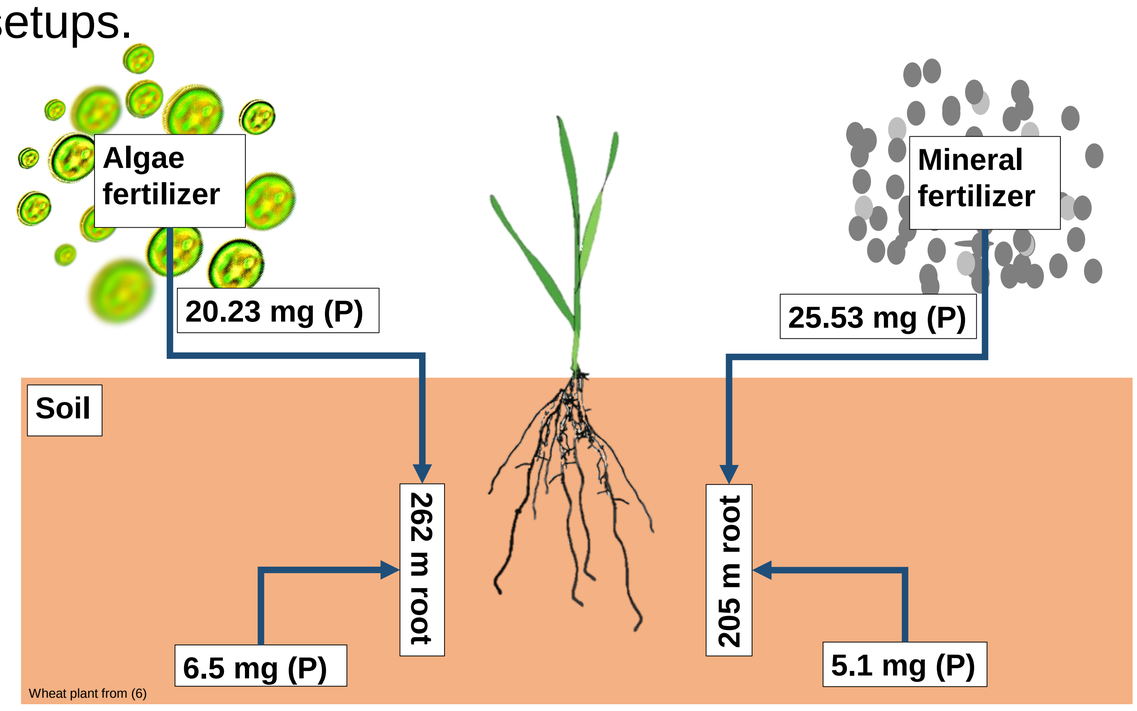
Metabolomics

Differences in uptake mode and response will very likely be reflected in the metabolome of the root, and be analysed by different metabolomics platforms.

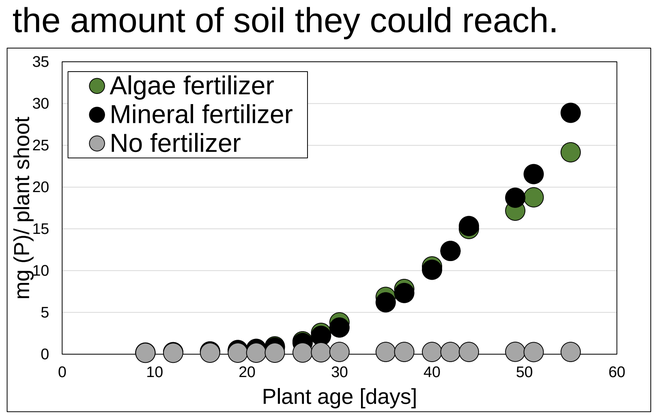
Next step: Understanding the metabolic response of wheat to algae to understand the uptake mode.

Mass-Balance Model of P uptake from algae

Quantification and estimation of complicated system helps identify needed parameters and to develop experimental setups.



The amounts of phosphorus taken up by the roots of wheat, modelled from Ref. 2. Calculation is based on dry-weight results from (ref. 2) in combination with specific root length values from ref. (4,5), which allow the calculation of root length. Root length is used to normalize single-plants to the amount of soil they could reach.



Approximated P over wheat age. Calculation is based on projected leave area in combination with dry-weight data (ref. 2). Growth is only possible with P, but both algae and mineral fertilizer show similar growth rates, hence similar uptake.

Next step: Identify the different P-Pools important for fertilization, their origin, transformation and uptake.

Next steps…

- Establishment of hydroponic system for algal fertilization;
- Its conversion into the EcoFAB setup;
- Production of EcoFABs cultivation setups for wheat and *B. distachyon*.

..and challenges ahead!

- Find the ideal size and nutrient concentration in the EcoFABs
- Optimize growth conditions and extractions for metabolomics platforms
- Find methods for separation of P forms in algae

References

1. A. Solovchenko, A. M. Verschoor, N. D. Jablonowski, L. Nedbal, *Biotechnol. Adv.* **34**, 550–564 (2016).
2. C. Schreiber *et al.*, *J. Appl. Phycol.* **30**, 2827–2836 (2018).
3. J. Gao *et al.*, *J. Vis. Exp.*, 1–16 (2018).
4. A. K. Løes, T. S. Gahoonia, *Euphytica*. **137**, 243–249 (2004).
5. V. Figueroa-Bustos, J. Palta, Y. Chen, K. Siddique, *Agronomy*. **8**, 109 (2018).
6. C. H. Kong *et al.*, *Nat. Commun.* **9** (2018), doi:10.1038/s41467-018-06429-1.
Chlorella vulgaris: https://www.algomed.de/chlorella/; Pipeline: https://stoneenvironmental.com/market/water-wastewater/; Algae bloom :http://www.spiegel.de/wissenschaft/natur/bild-891963-479188.html