Quantifying and mapping citrate exudation in soil-grown root systems

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1. Introduction

Root exudates

- Root derived **primary** and **secondary** metabolites

- **Exuded** by the plants into the rhizosphere

- **Rhizosphere** is ‘the volume of soil that is influenced by root activity’ (P. Hinsinger, 1998)

1. Introduction

Root exudates

Up to 27% of the C allocated to roots

Secondary metabolites

Organic acids

Phenols

Amino acids

Proteins
1. Introduction

Citrate exudation

- Huge role in P acquisition

- **Solubilisation** of P bound to iron or aluminum (hydro)oxides

- P deficiency triggers an **overexpression** of the protein responsible for citrate exudation

- Knowledge about the **quality, quantity and spatial allocation** of citrate is of immense importance to understand plant performance and ultimately optimize agricultural productivity and quality
1. Introduction

Citrate sampling

- Difficulties to sample and localize root exudates such as citrate:
  - Microbial degradation
  - Sorption to solid soil phase

- Most applied methods do not represent the “real field conditions”

Aim:
This study aims to develop a passive sampling, localization, quantification and imaging technique for citrate exuded from plant roots grown in rhizotrons
2. Method development

- Based on Diffusive Gradients in Thin Films (DGT)
- ZrOH polyacrylamide hydrogel
- **Characterization** of ZrOH gels for citrate sampling
  - Adsorption kinetics
  - Elution efficiency
  - Capacity

- Quantification and localization of citrate in a non-destructive way from soil-grown roots

\[ C_{DGT} = \frac{M \Delta g}{D t A} \]
3. Results

Results - Gel characterisation

*Adsorption kinetics*

- ZrOH is *feasible* as citrate binding agent

- *Citrate elution efficiency*
  - 0.5 M NaOH for 24 h
  - 89%
3. Results

Results - Gel characterisation

*Capacity*

- pH 4 = 95 ± 5 µg citrate cm\(^{-2}\) gel
- pH 8 = 64 ± 2.2 µg citrate cm\(^{-2}\) gel

\[
C_{DGT} = \frac{M\Delta g}{DtA}
\]
3. Results

Plant experiment
3. Results

Results – Plant experiment

Citrate $\mu g \text{ cm}^{-2}$
4. Conclusion

- Citrate sampling with ZrOH gels could represent an easy and reliable method for soil sampling and be an alternative to already established sampling methods.

- Changing binding materials, this approach may be used also for other compound classes.

- Combination of other imaging techniques.
Thank you for your attention!