

Beyond growth?

The significance of microbial maintenance for carbon-use efficiency in the light of soil carbon storage

Tobias Bölscher, Melanie Brunn, Tino Colombi, Luiz A. Domeignoz-Horta, Anke M. Herrmann, Katharina H.E. Meurer, Folasade K. Olagoke, Cordula Vogel

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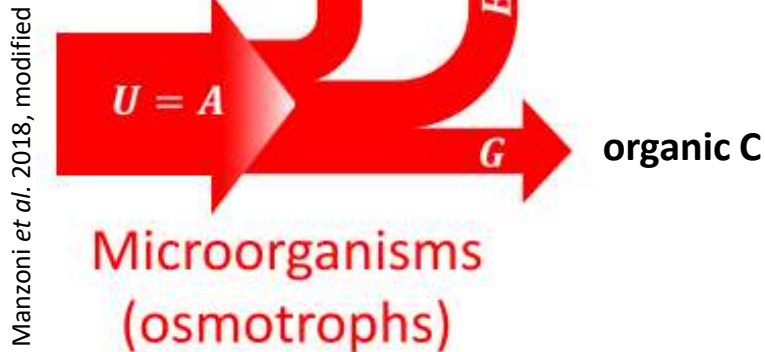
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Microbial CUE: An ambiguous concept

What we measure:

$$CUE = \frac{\textit{growth}}{\textit{respiration} + \textit{growth}}$$



U = uptake

A = assimilation

R = respiration

EX = exudation

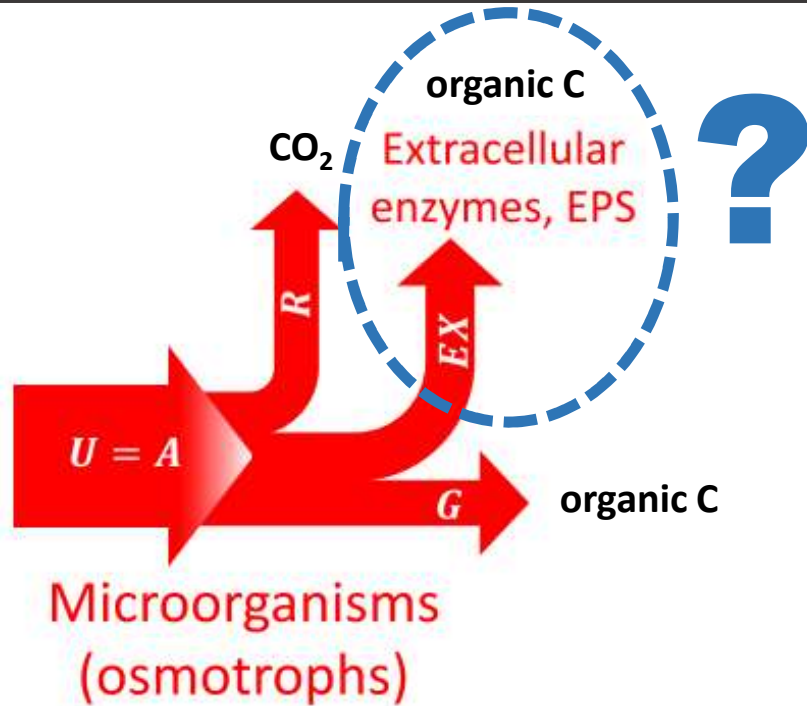
G = net growth

CUE = carbon use efficiency



Microbial CUE: An ambiguous concept

Manzoni et al. 2018, modified



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R = respiration
EX = exudation
G = net growth
CUE = carbon use efficiency

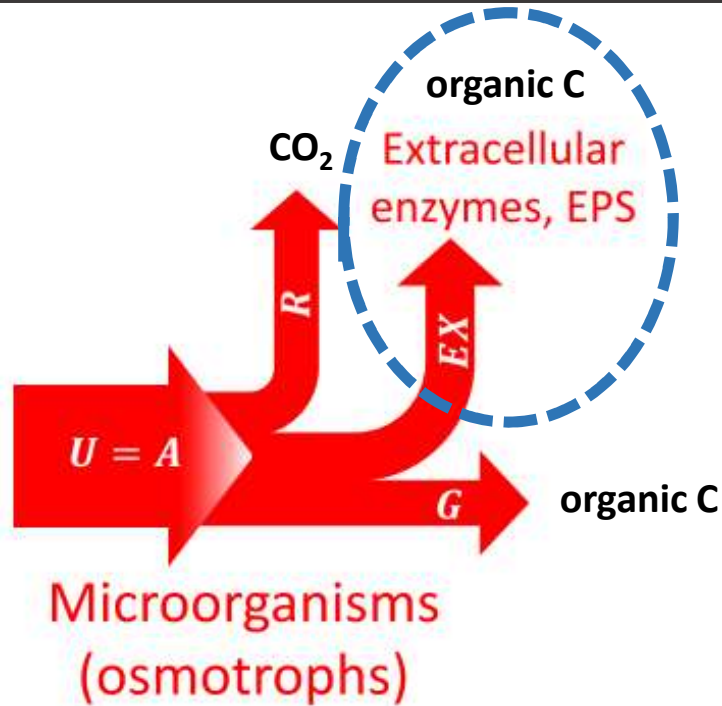
What we measure:

$$CUE = \frac{\text{growth}}{\text{respiration} + \text{growth}}$$

→ **Apparent CUE !**

Microbial CUE: An ambiguous concept

Manzoni et al. 2018, modified



U = uptake
A = assimilation
R = respiration
EX = exudation
G = net growth
CUE = carbon use efficiency

What we measure:

$$CUE = \frac{\textit{growth}}{\textit{respiration} + \textit{growth}}$$

→ Apparent CUE

What we should measure:

$$CUE = \frac{\textit{growth} + \textit{exudation}}{\textit{respiration} + \textit{growth} + \textit{exudation}}$$

→ Actual CUE



Question

Quantitative differences in *actual* and *apparent* CUE?

What we measure:

$$CUE = \frac{growth}{respiration + growth}$$

→ Apparent CUE

What we should measure:

$$CUE = \frac{growth + exudation}{respiration + growth + exudation}$$

→ Actual CUE

Question

Quantitative differences in *actual* and *apparent* CUE?

What we measure:

$$CUE = \frac{growth}{respiration + growth}$$

→ Apparent CUE

What we should measure:

$$CUE = \frac{growth + exudation}{respiration + growth + exudation}$$

→ Actual CUE

Predicting Long-Term Soil Carbon Storage from Short-Term Information

Riitta Hyvönen,* Göran I. Ågren, and Ernesto Bosatta

Published in Soil Sci. Soc. Am. J. 62:1000–1005 (1998).

→ CUE one of the most sensitive factor in soil C model!

Extracellular enzymes

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DOI: 10.1111/gcb.16544

RESEARCH ARTICLE

Global Change Biology WILEY

Substrate availability and not thermal acclimation controls microbial temperature sensitivity response to long-term warming

Luiz A. Domeignoz-Horta^{1,2}  | Grace Pold³  | Hailey Erb¹  | David Sebag^{4,5}  | Eric Verrecchia⁵ | Trent Northen^{6,7} | Katherine Louie⁷  | Emiley Eloie-Fadrosch⁷  | Christa Pennacchio⁷ | Melissa A. Knorr⁸ | Serita D. Frey⁸  | Jerry M. Melillo⁹ | Kristen M. DeAngelis¹ 

Field site: Harvard Forest Long-term Ecological Research

Soil warming experiments:

- 13 years
- 28 years

Treatments:

- ambient
- +5 °C

Sampling time:

- July 2019
- October 2019

Sampling depth: 0-10 cm

Analyses:

- **Microbial CUE** (¹⁸O-water tracing)
- **Enzyme activity** (N-acetylglucosaminidase, phenol oxidase, peroxidase)

- ➔ **Enzyme turnover**
- ➔ **Enzyme C pool size**

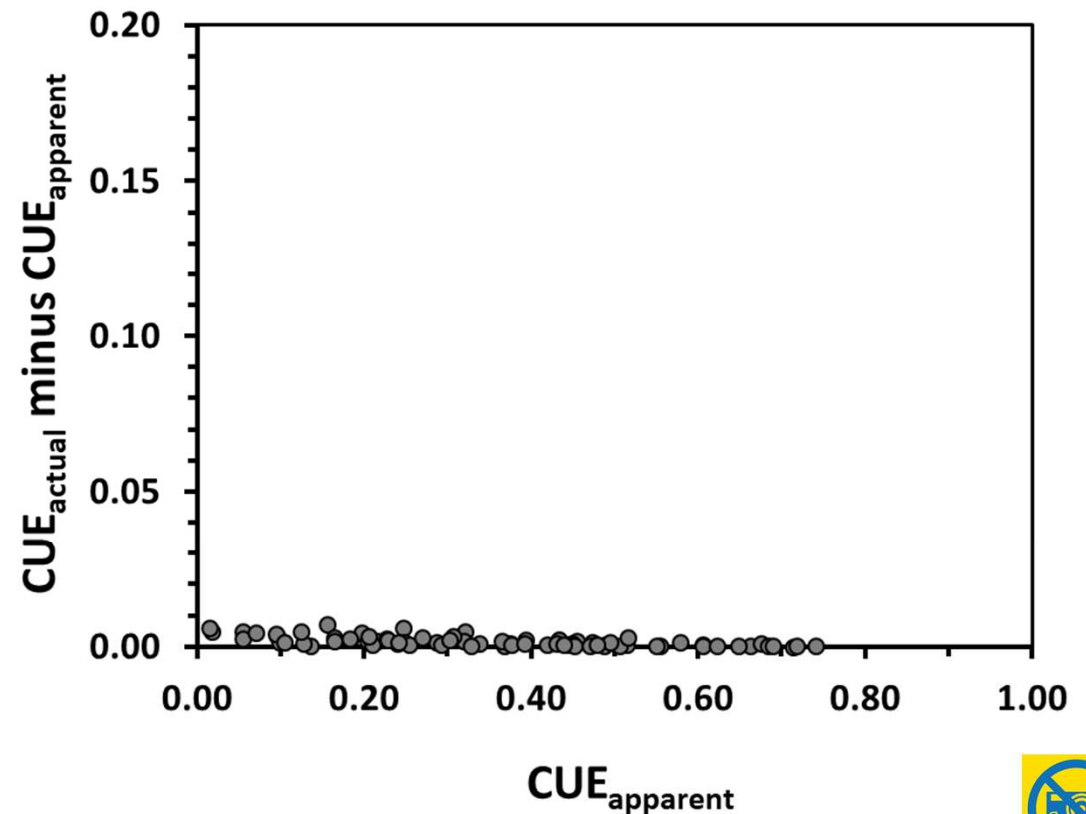
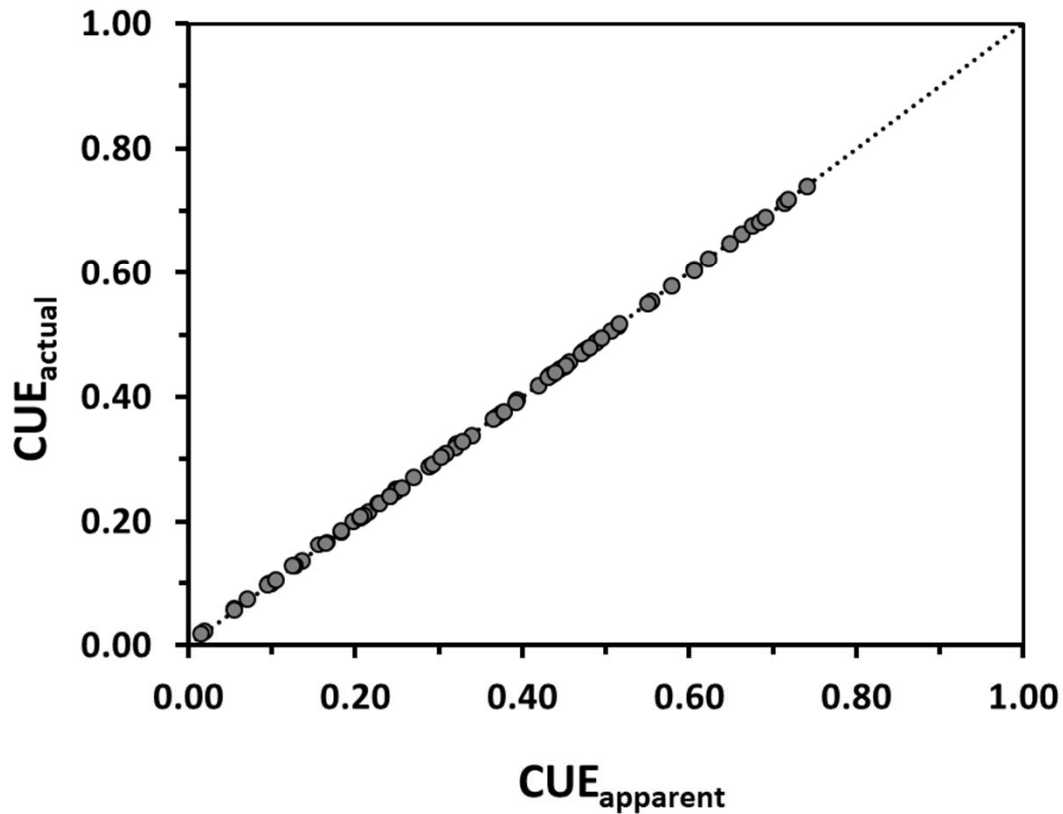


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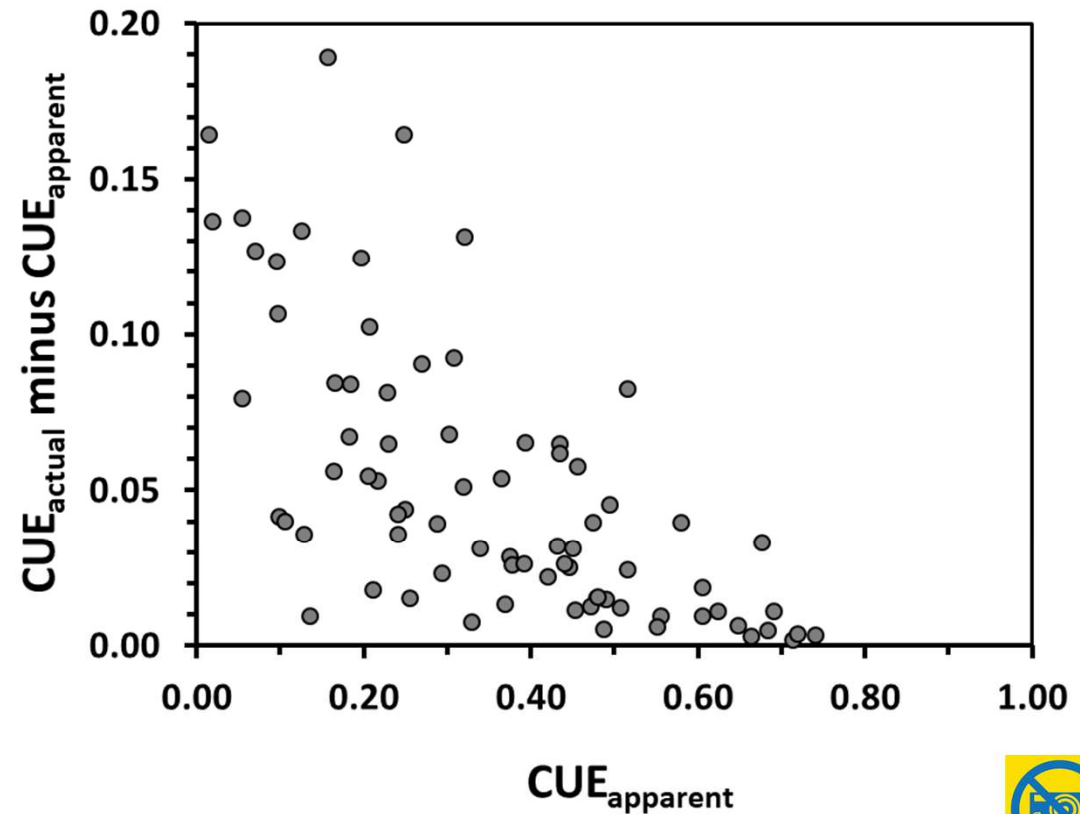
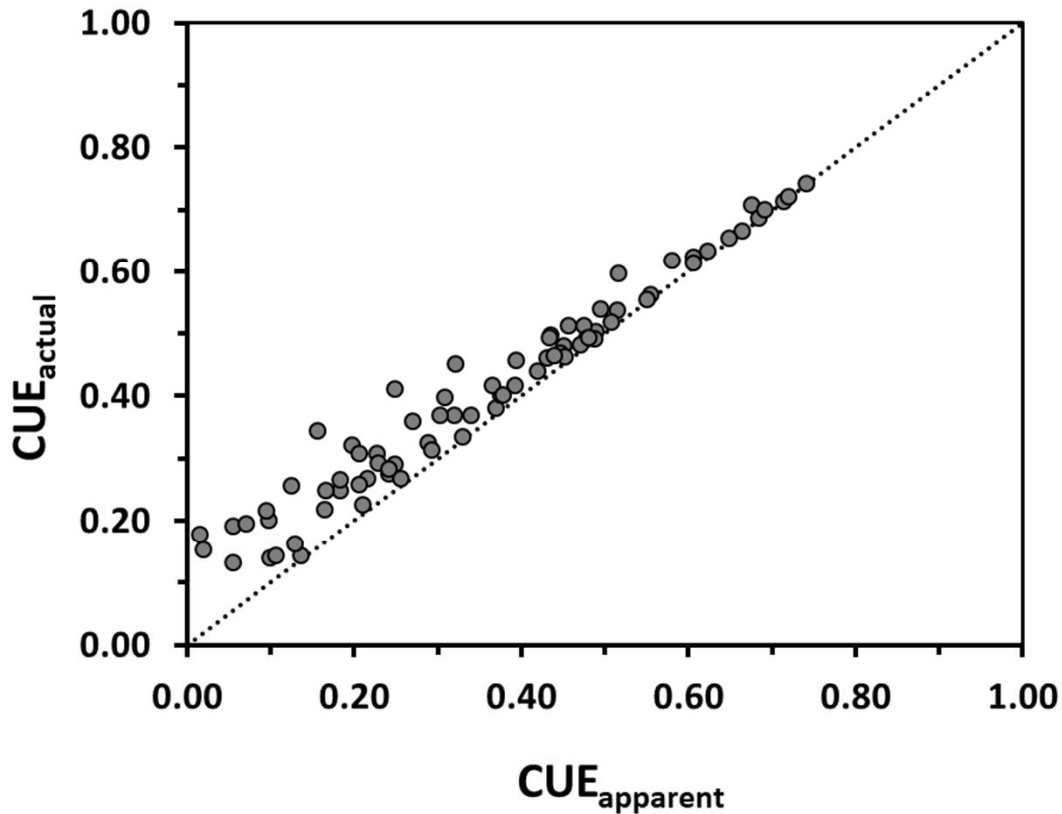
Extracellular enzymes

Maintaining the existing exoenzyme pool (i.e. enzyme turnover)



Extracellular enzymes

Increasing the exoenzyme pool by 20 % (i.e. enzyme pool expansion)



Extracellular polymeric substances (EPS)

Biology and Fertility of Soils (2022) 58:435–457
<https://doi.org/10.1007/s00374-022-01632-1>

ORIGINAL PAPER



Importance of substrate quality and clay content on microbial extracellular polymeric substances production and aggregate stability in soils

Folasade K. Olagoke¹ · Antje Bettermann² · Phuong Thi Bich Nguyen³ · Marc Redmile-Gordon⁴ · Doreen Babin² · Kornelia Smalla² · Joseph Nesme⁵ · Søren J. Sørensen⁵ · Karsten Kalbitz¹ · Cordula Vogel¹

Analyses:

- **Microbial biomass carbon**
- **Extracellular polymeric substances** (polysaccharides, proteins)

- No cumulative respiration → CUE_{apparent} assumed to be 0.10 – 0.80

Incubation experiment:

Pre-treatments:

- 1st pre-incubation to remove labile OM
- Removal of POM
- Aggregate crushing
- 2nd pre-incubation for microbial adaptation

Treatments:

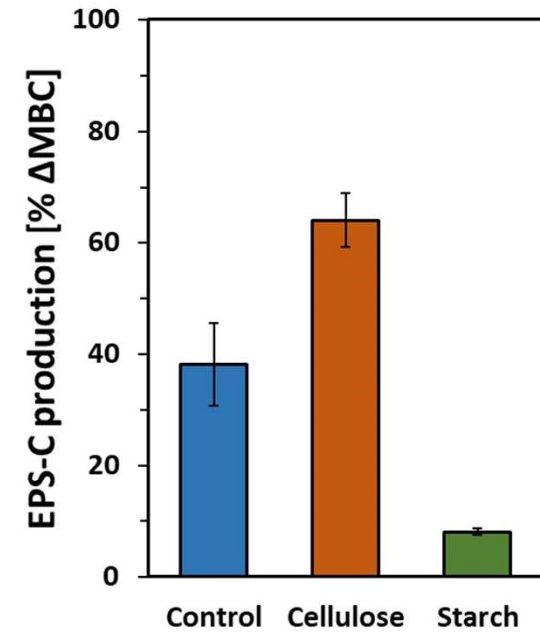
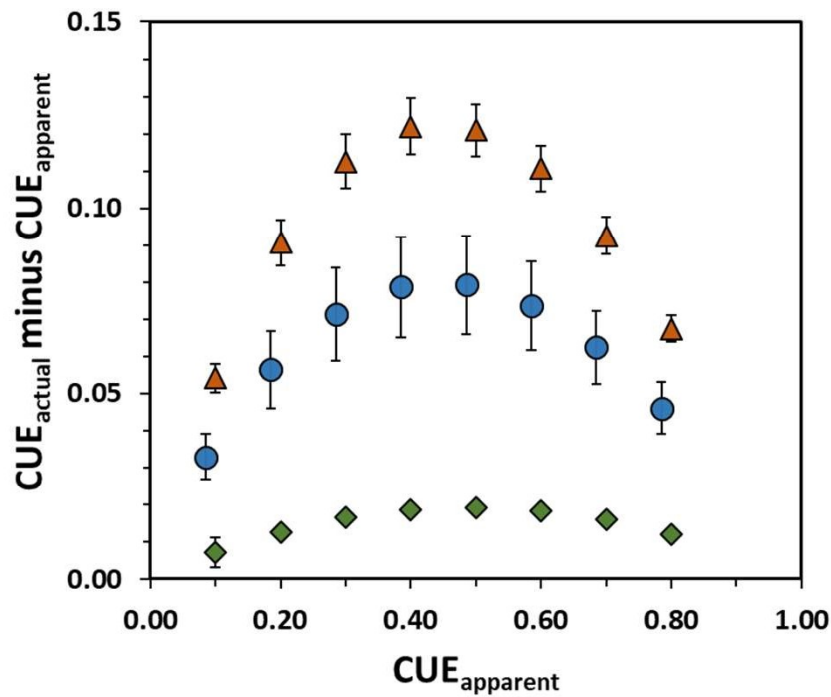
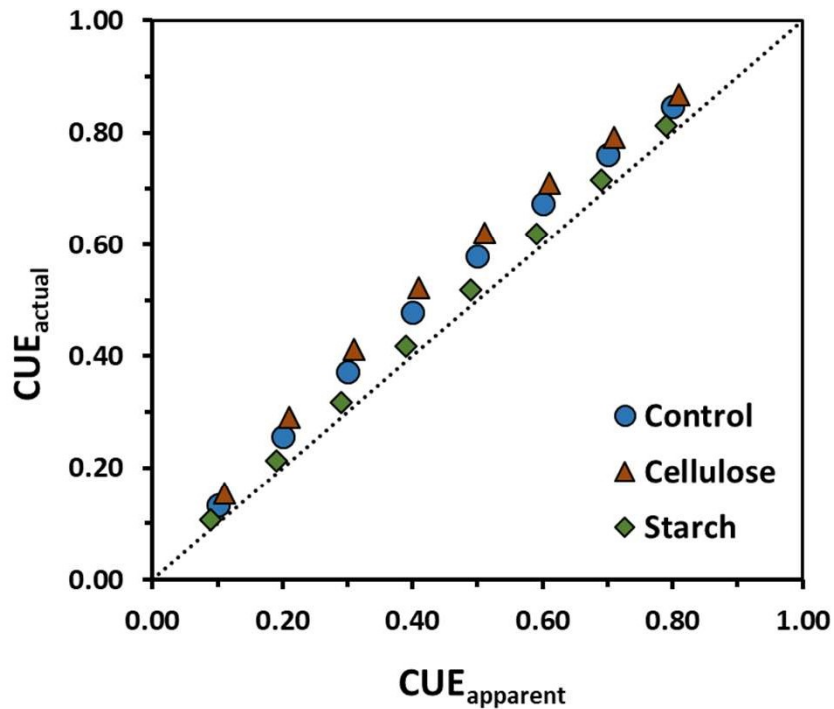
- Clay addition: +0, +0.1, +1, +10 % clay
- Substrate addition: **cellulose, starch, control**

Sampling harvest:

- Days **0, 3, 10, 20, 40, 80**



Extracellular polymeric substances (EPS)



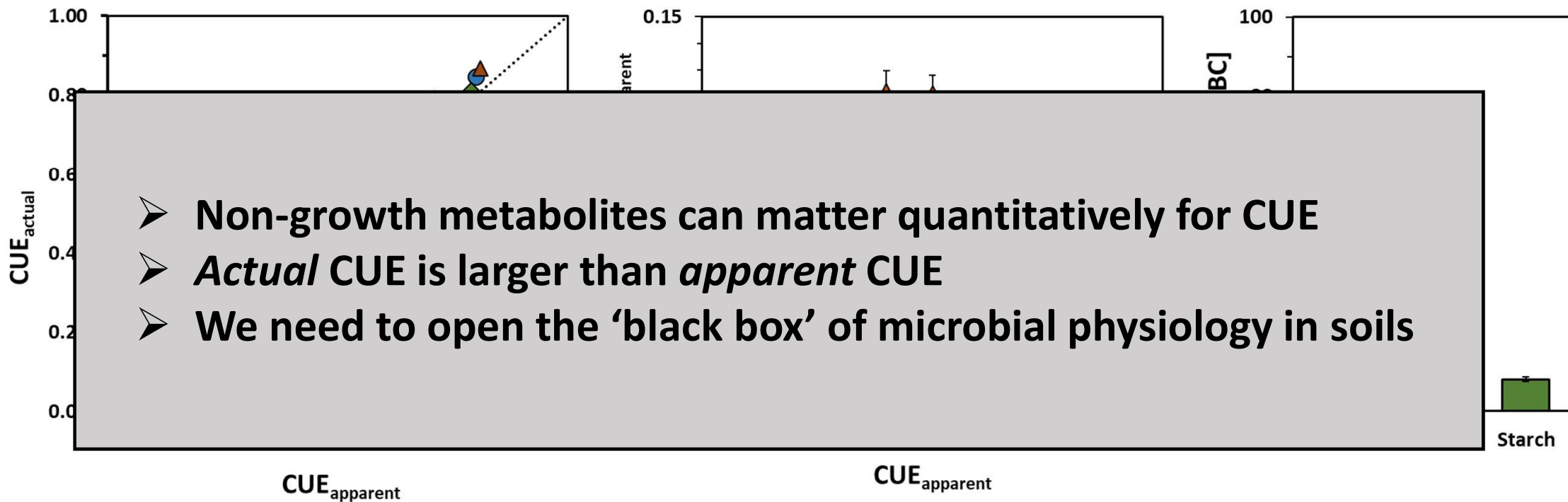
Results for:

- +1 % clay treatments
- Changes between day 0 and 3 in MBC + EPS

EPS-C = extracellular polymeric substances carbon
 MBC = microbial biomass carbon



Extracellular polymeric substances (EPS)



Results for:

- +1 % clay treatments
- Changes between day 0 and 3 in MBC + EPS

EPS-C = extracellular polymeric substances carbon
MBC = microbial biomass carbon



Acknowledgments



Swedish University of
Agricultural Sciences



University of
Zurich ^{UZH}



uk university
of koblenz
continue discovering

 TECHNISCHE
UNIVERSITÄT
DRESDEN

INRAE

Thank you for your attention!

PhD possibilities:

**LEROI: Linking the Energetic Return-On-Investment to
microbial decomposition of organic soil amendments**

Start: second half 2023 (negotiable)
Paris-Saclay, France

Tobias Bölscher - tobias.bolscher@inrae.fr
Claire Chenu – claire.chenu@inrae.fr

Theoretical considerations

