Variation of Soil Microbial Community Structure and Activity along Ecohydrological Gradients

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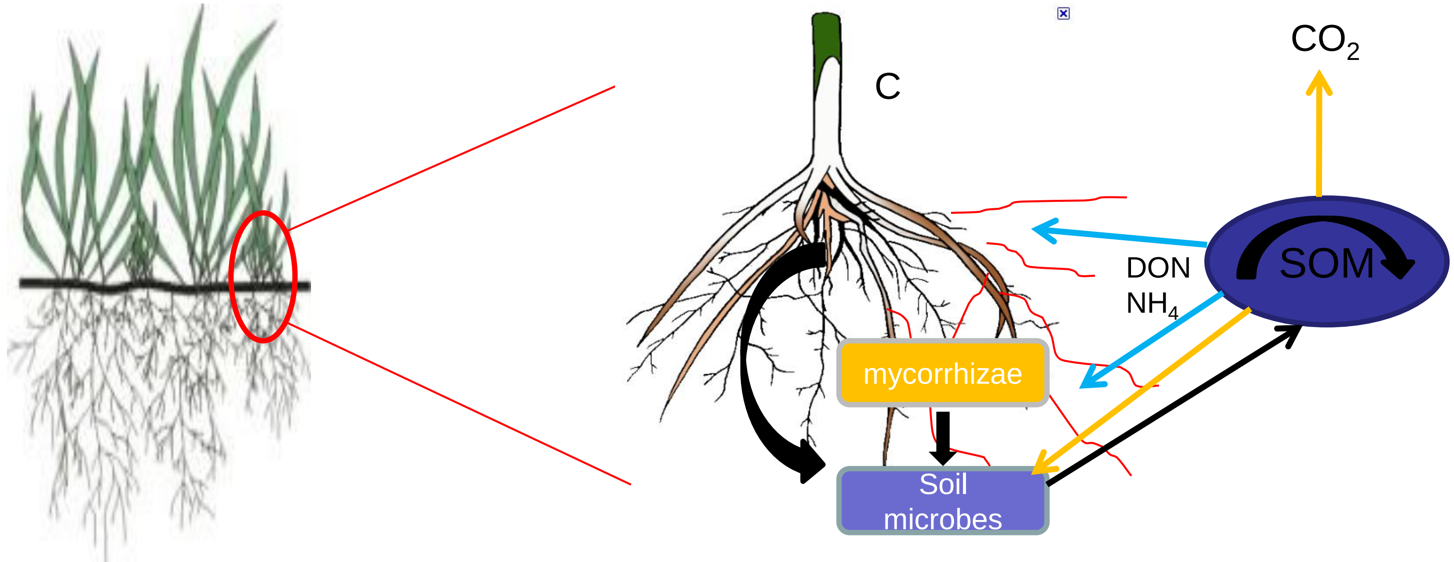
Mycorrhizosphere and C cycle



- Rhizosphere = major sink for photo-assimilated C and hot-spot for microbial activity
- Microbes allocate assimilated C to growth, respiration or metabolite (enzyme) production, with consequences for soil C stabilization and nutrient cycling
- Tracking photosynthate into and through the soil microbial community and plant-microbe dynamics has become a topic of wide interest for understanding ecosystem functioning (plant growth, C and N cycling) in a changing environment

Temporal variation in wetland vegetation

0-40% of total plant C => belowground

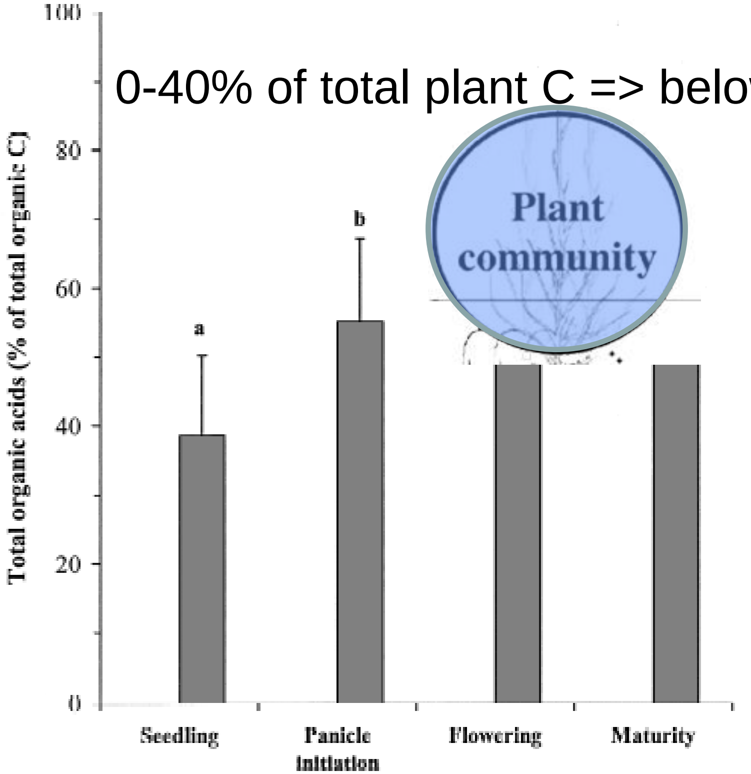
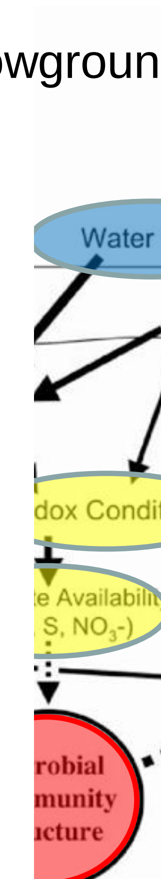
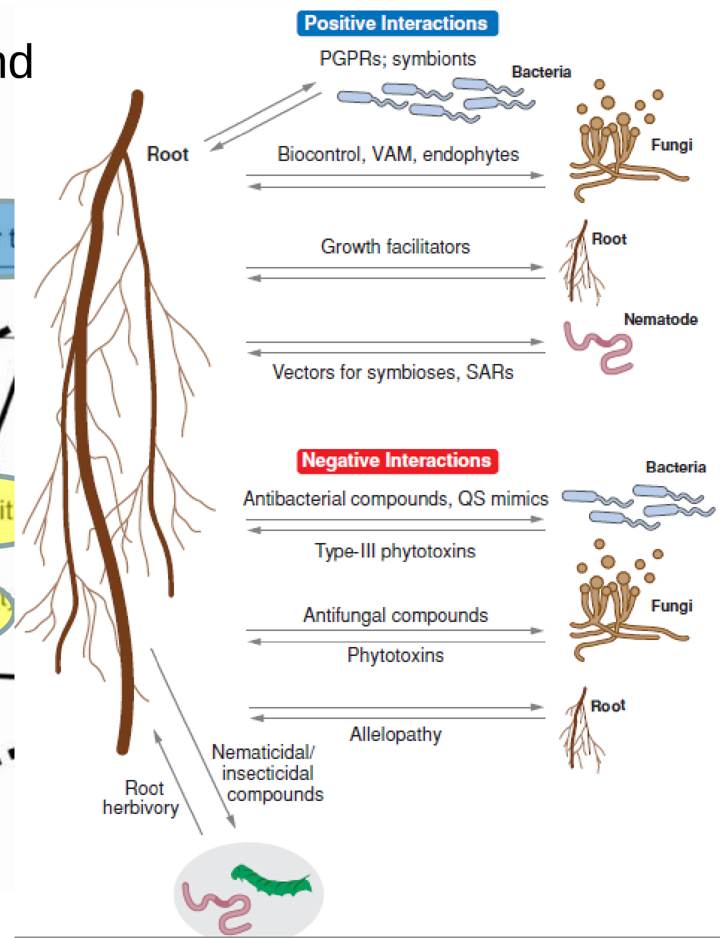
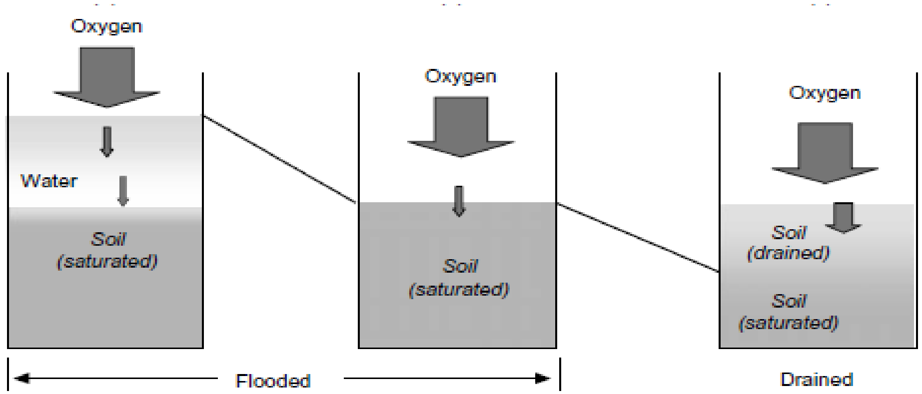


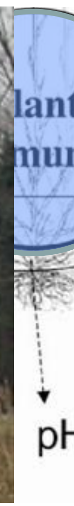
Fig. 4 Proportion of organic acids in total organic C released from the roots of rice plants at four growth stages (average of 10 cultivars). Data shown are means ± SD of 30 plants (10 cultivars × 3 replicates). Different letters indicate significant differences between growth stages ($p \geq 0.05$).

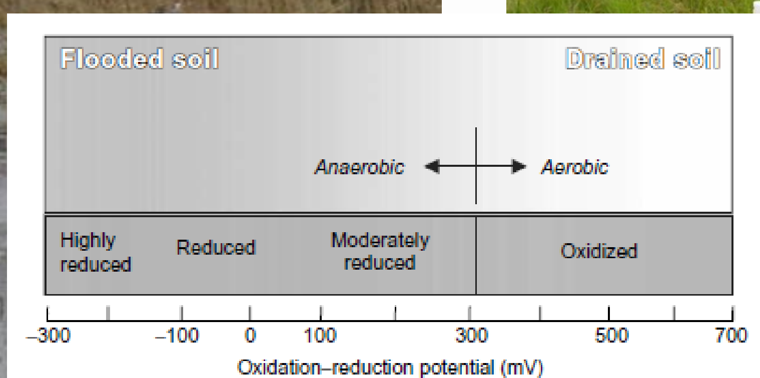




Temporal variation in wetland hydrology

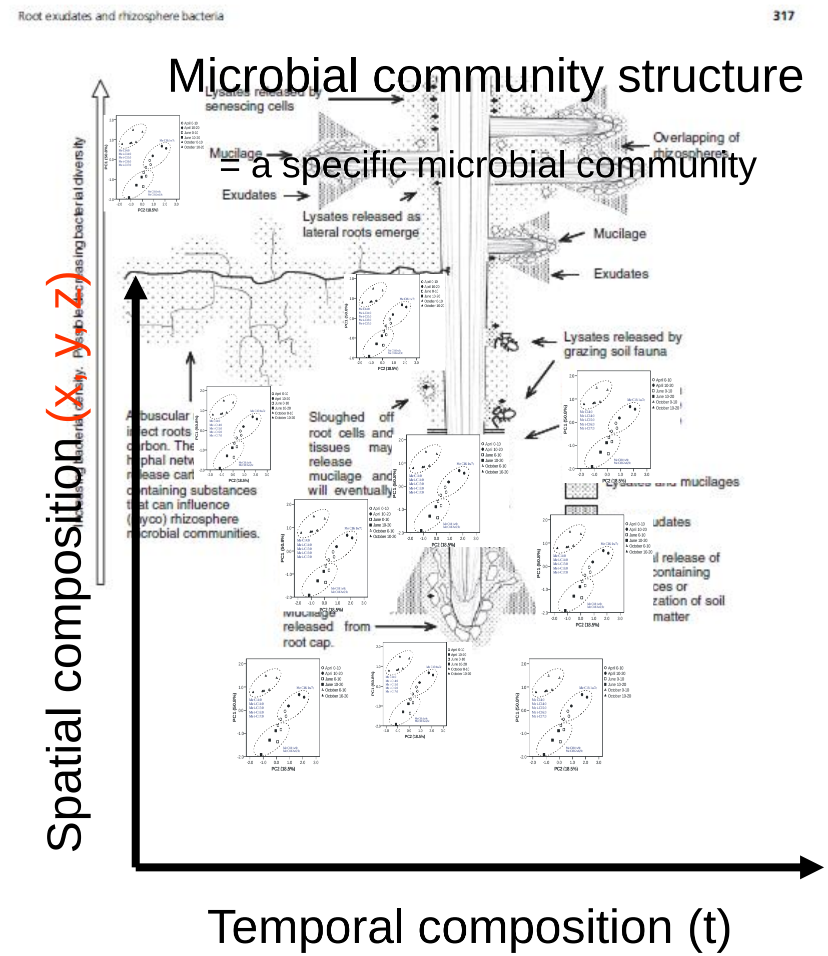






Study objectives

The objective of this work was to study variations in *__microbial communities active in rhizodeposit-C assimilation__* as a function of time and space in wetlands of Belgium and Poland.



Methodology: PLFA based SIP

PLFA

Introduction

PLFAs 'specific' for different microbial communities

Microbial group	Fatty acids (FAs)	Source
Gram-ncgativc bacteria	OH FAs (usually 3 OH)	Cavigelli et al. (1995)
	monounsaturated FAs (e.g. 16:1w7t, 16:1wSc, 18:1w7)	Zclles (1999a),
	cy17:0, cy19:0	Zelles (1999b)
Gram-positive bacteria	Iso- and anteiso FAs (e.g. i15:0, A15:0, i16:0, i17:0, a17:0)	Pennanen et al. (1998), Zelles (1999a,b)
Actinomycetales	10 Me FAs (e.g. 10 Mc16:0, 10 Me17:0, 10 Me18:0)	Frostegård et al. (1993), Kelly et al. (1999)
Cytophaga–Flavobacterium–Bacteroides	16:1w5c	Frostegård et al. (1993), Kelly et al. (1999)
	FAs with odd number of C	Olsson and Persson (1999)
Pseudomonas	16:0 and 16:1w7c (equiv. proportions), 18: 1w7c/w9t/w12t	Haack et al. (1994)
	FAs with even number of C	Olsson and Persson (1999)
Arthrobacter	a15:0 and a17:0 (high proportions)	Haack et al. (1994)
Fungi	16:1wSc (in arbuscular fungi)	Olsson (1999)
	1 8:2w6,9c	Frostegård et al. (1993, 1996)
	18:1w9c, 20:4	Lindahl et al. (1997)
	23:0, 25:0, 21:0	Zelles (1999b)
Eukaryotic algae and *Protozoa*	Polyunsaturated FAs (e.g. 16:1w4, 16:3, 18:4w3, 20:4, 20:5, 22:6)	Findlay (1996), Frostegård et al. (1997)

CO_2 monitor (EGM-4 PP systems)

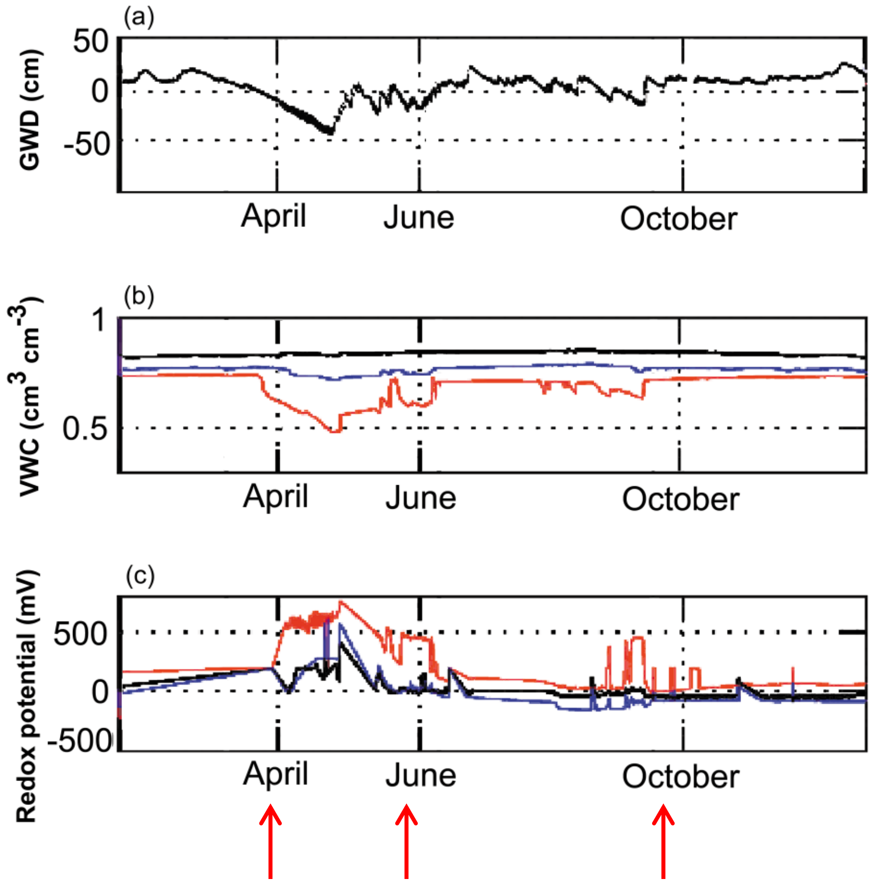
Plexiglass chamber

Stainless-steel frame

fans

Tubes carrying gas to the monitor

Case study I: Temporal variations in hydrology

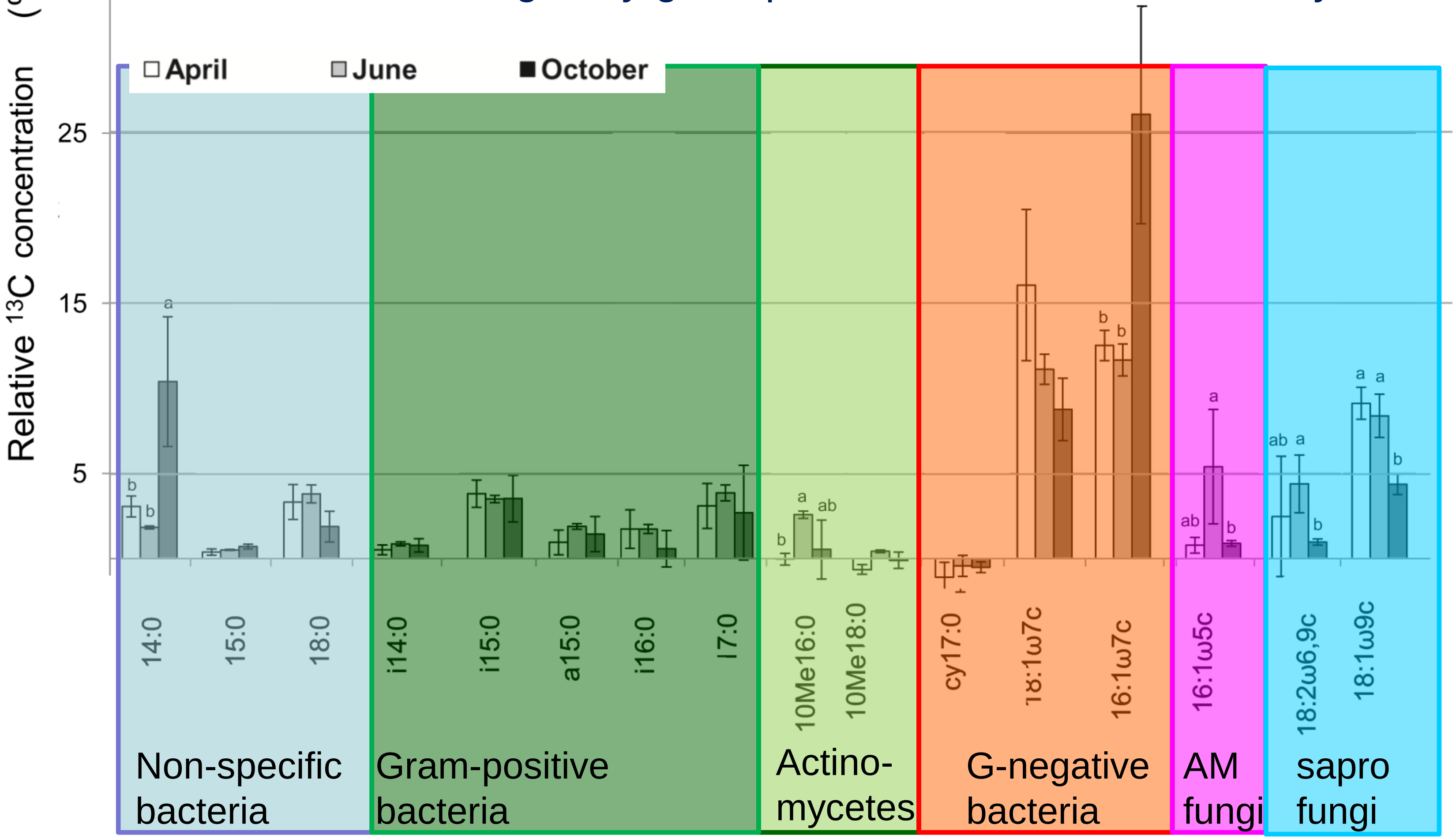


$^{13}CO_2$ pulse labeling

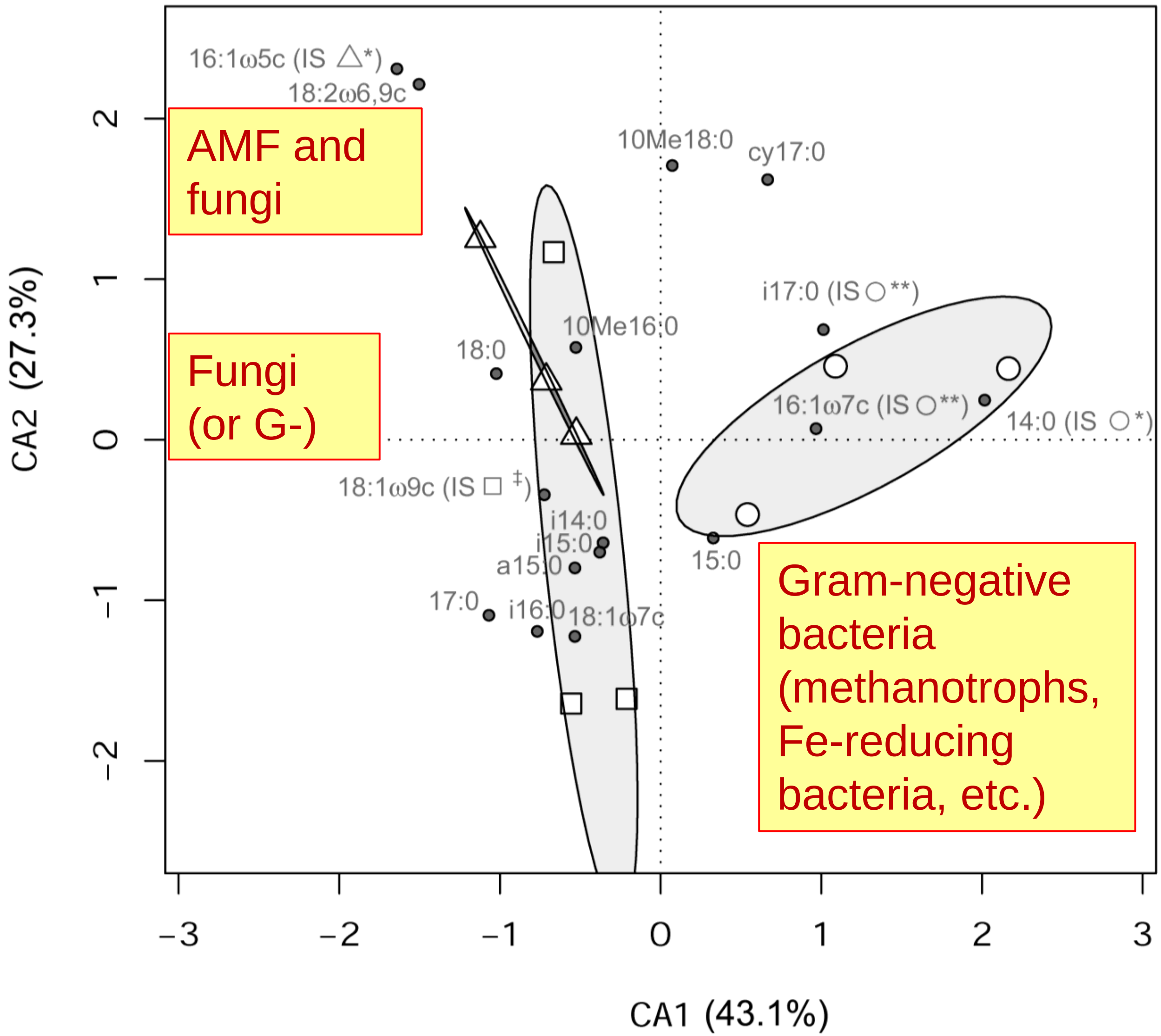
Sampling after 24h => short term rhizodeposit ^{13}C uptake.

Relative ^{13}C concentration

⇒Some PLFAs vary in their efficiency to assimilate ^{13}C, other don't
⇒ Low ^{13}C labelling of by gram-positive bacteria and actinomycetes



Relative ^{13}C concentration



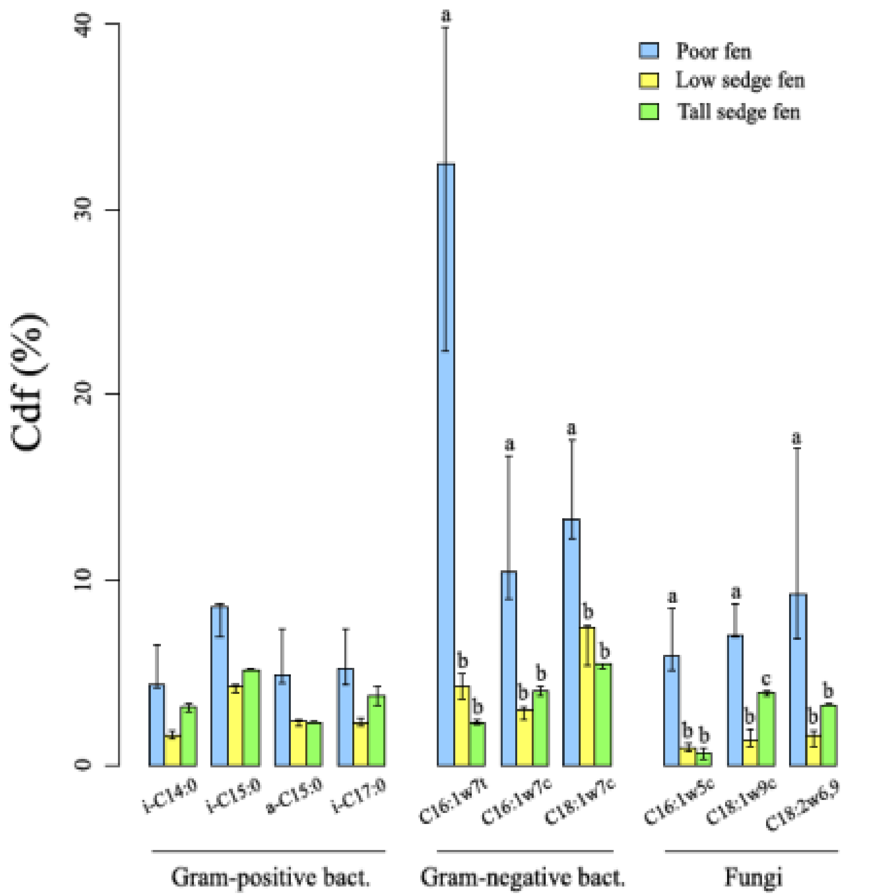
1. Permutation tests showed a significant effect of time (P=0.02) on $^{13}CC_r$.
2. Separation between microbial communities involved in 13C assimilation between April-June and October
3. Indicator species analysis: saprotrophic fungi in April, AMF in June, bacteria in October.

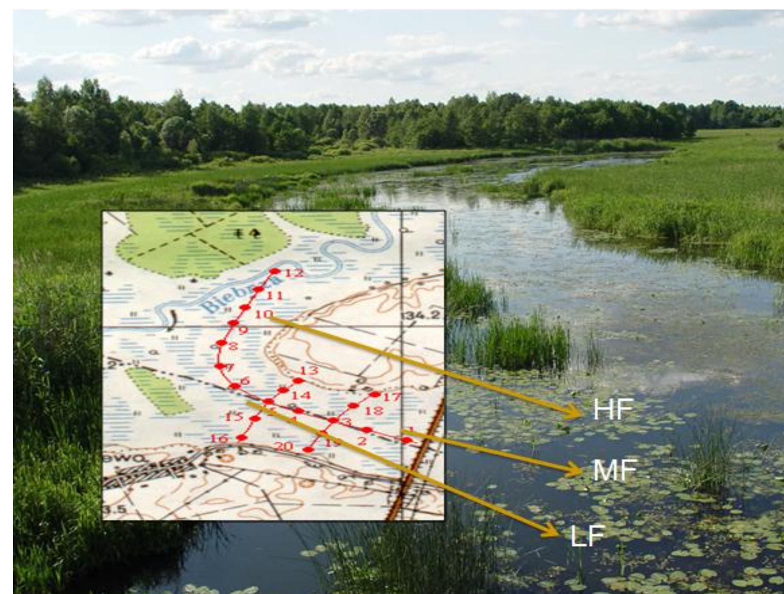
April, June and October samples are represented by □, Δ and ○, respectively;

Case study II: Bierbza wetlands in Poland

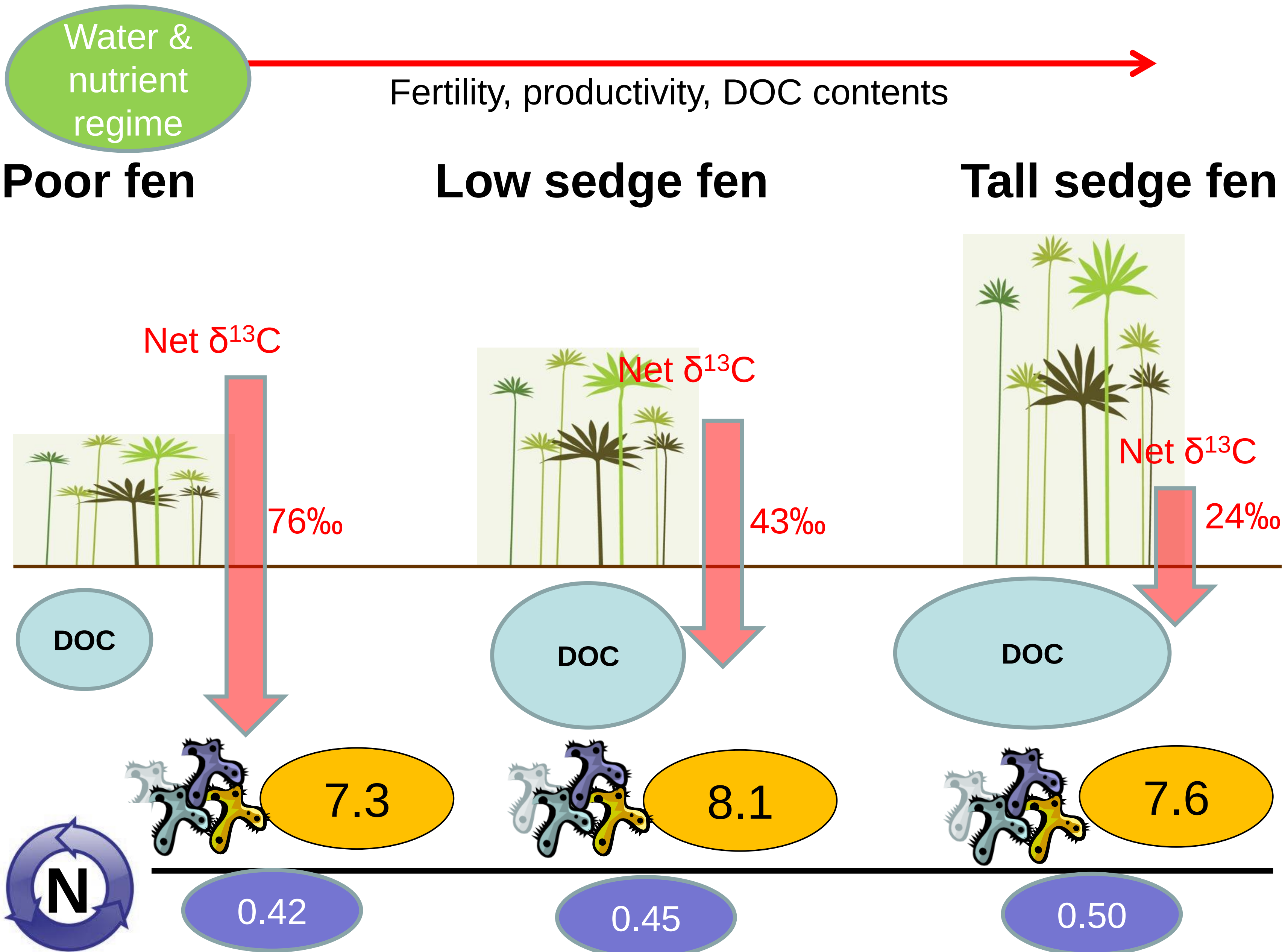
Study of three wetlands:

PLFA-SIP and tracing $^{13}CO_2$ in microbial communities one day after labeling.



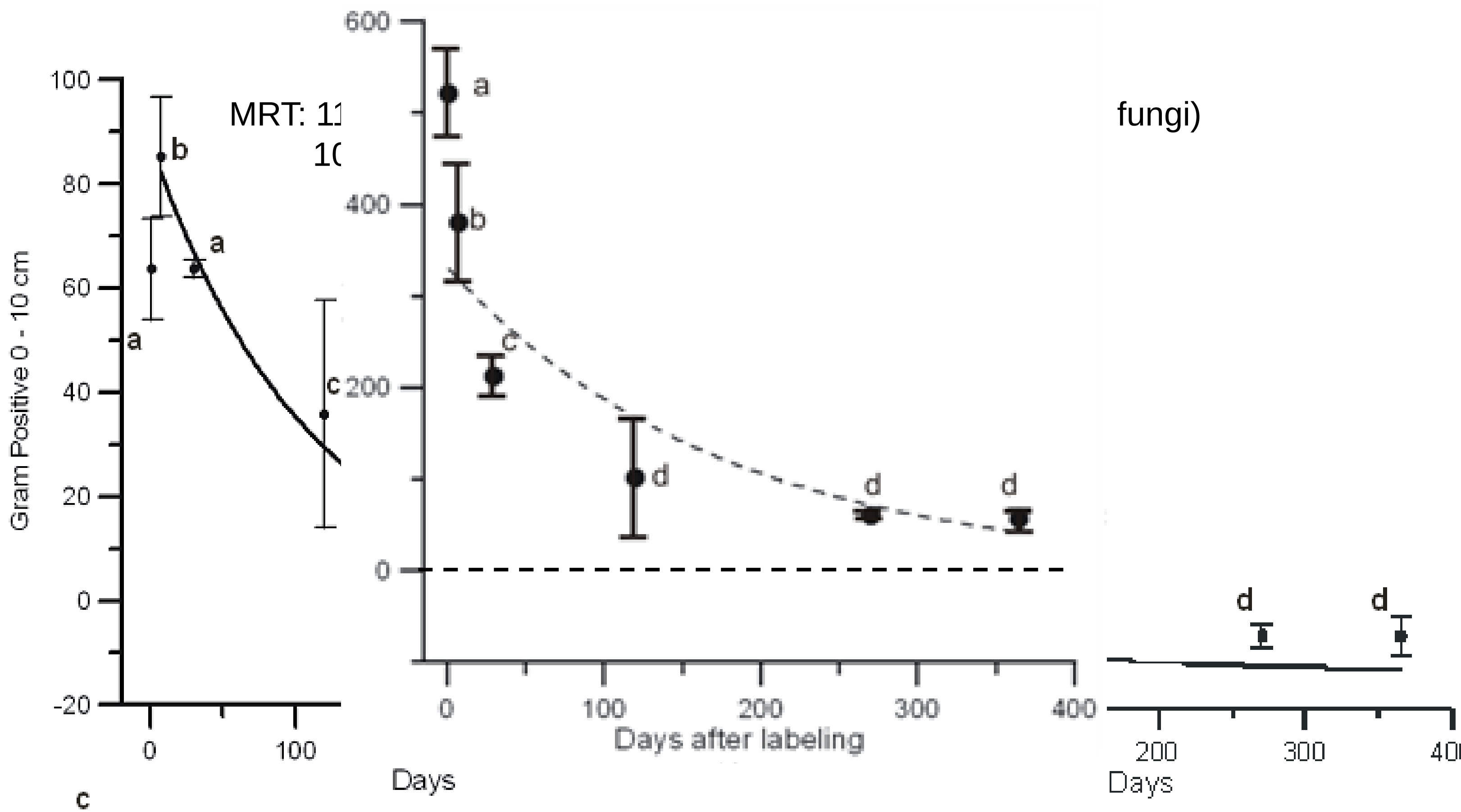


Case study II: Biebrza wetlands in Poland

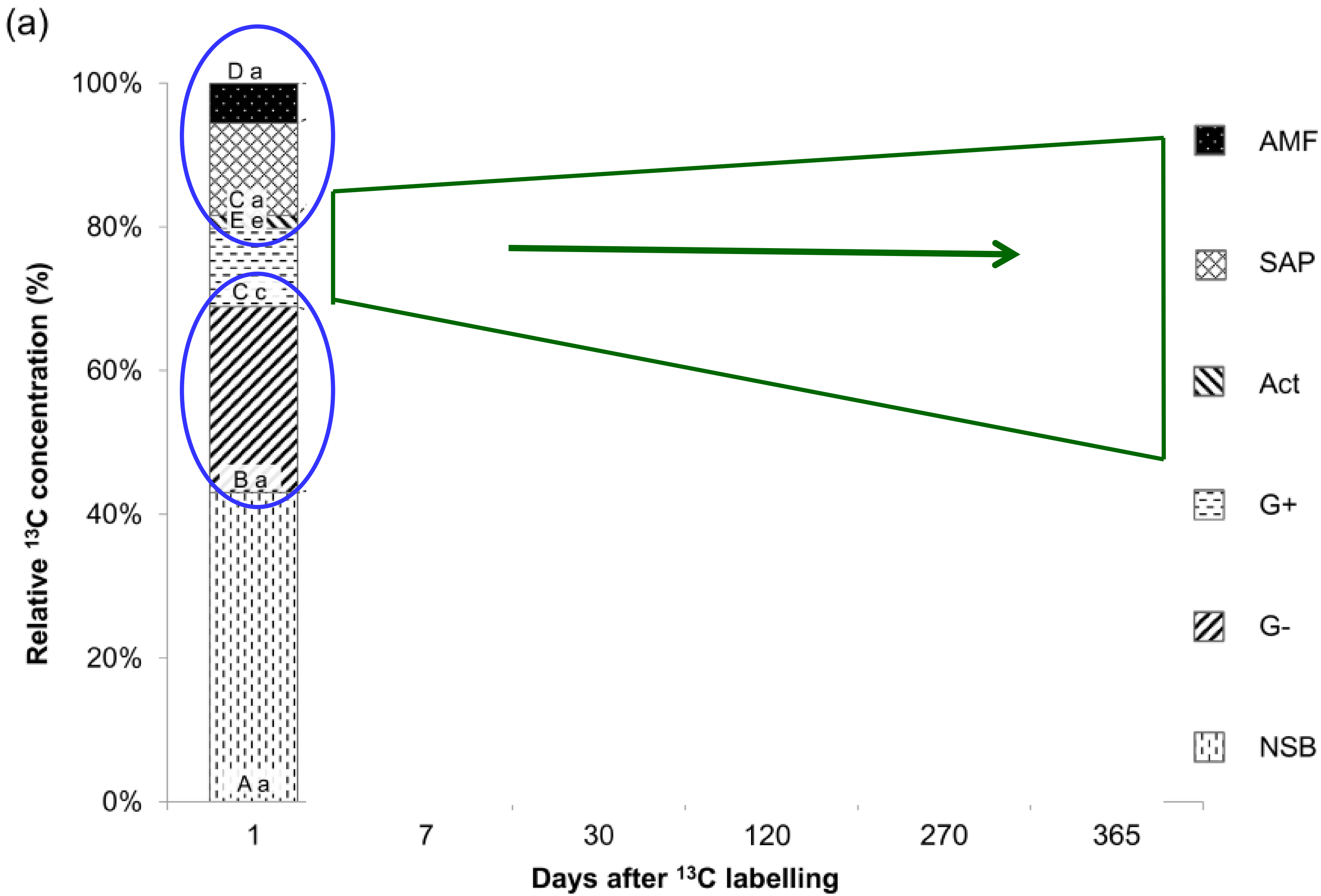


Case study III: recycling of ^{13}C within microbial communities

- Microbes rapidly take up rhizodeposit C (within hours/days) suggesting tight coupling between microbial and plant activity
- What happens next? What is the fate of ^{13}C present in the PLFAs?



Case study III: recycling of ^{13}C within microbial communities



Conclusions

- Microbes rapidly take up rhizodeposit C (within hours/days) suggesting tight coupling between microbial and plant activity
- Allocation of plant assimilates to microbes is linked to plant physiology and environmental factors
- Most rapid uptake of rhizodeposit C by selective communities, though varies with plant, soil and environmental factors
- (symbiotic) fungi appear to play a key role in channeling rhizodeposit-C to the soil microbial community
- Large proportion of microbial-assimilated rhizodeposit-C may remain in biomass due to active recycling through the soil food web, and is further stabilized in microbial necromass/metabolites
- Rhizodeposition affects specific communities involved in key carbon and nitrogen transformation processes.

Acknowledgements

To ISOFYS – UGent

Dries Roobroeck, Oswald VanCleemput,, Mihiri Manimel Wadu, Jan Vermeulen, Eric Gillis, Jorin Botte