Rhizodéposition et séquestration/stockage de C dans les sols

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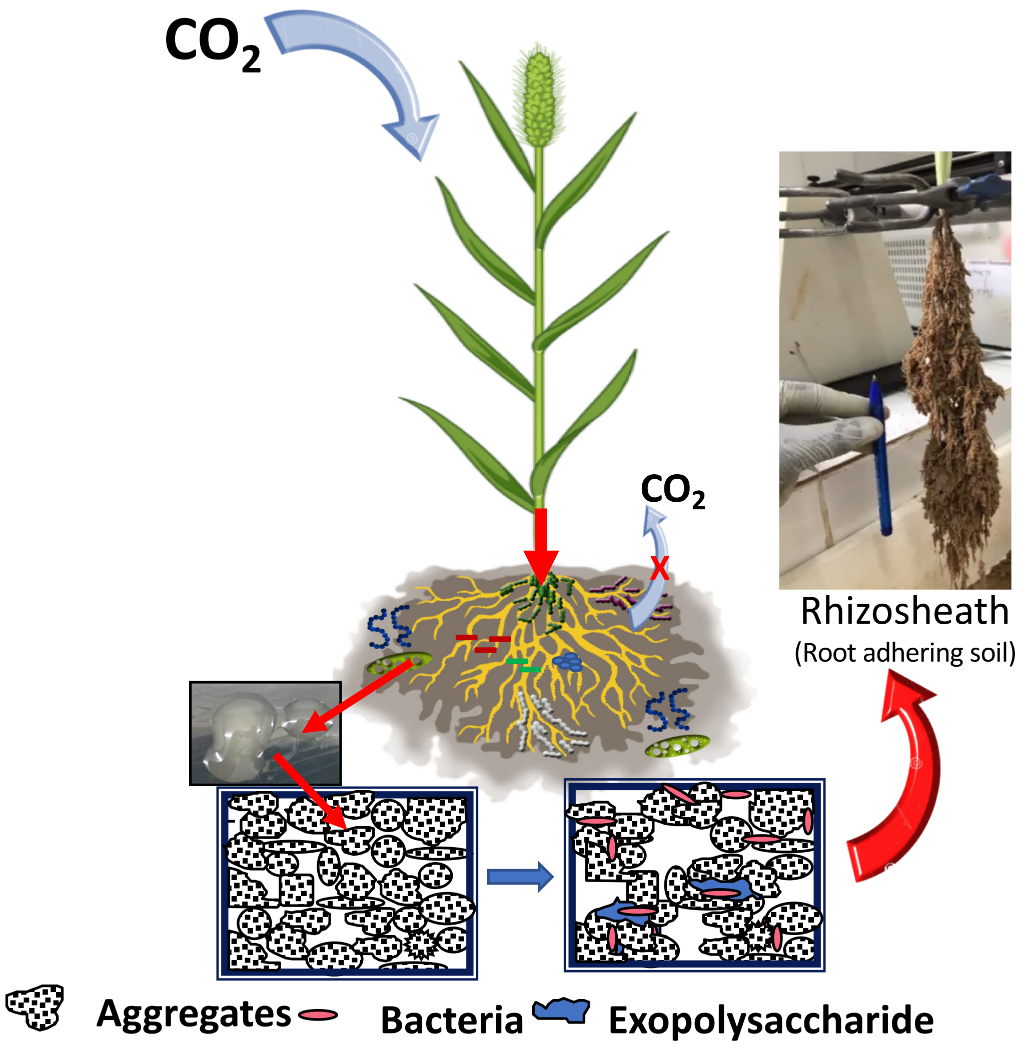
The limits of "classic" approaches to restoring organic matter to soils :

- Agroforestry could be a solution, albeit with certain constraints
- Spreading crop residues (straw), effluents or composts only enriches the soil surface and can sometimes lead to mineralization of existing C.

Can varietal selection be an alternative to conventional practices for returning C to the soil?

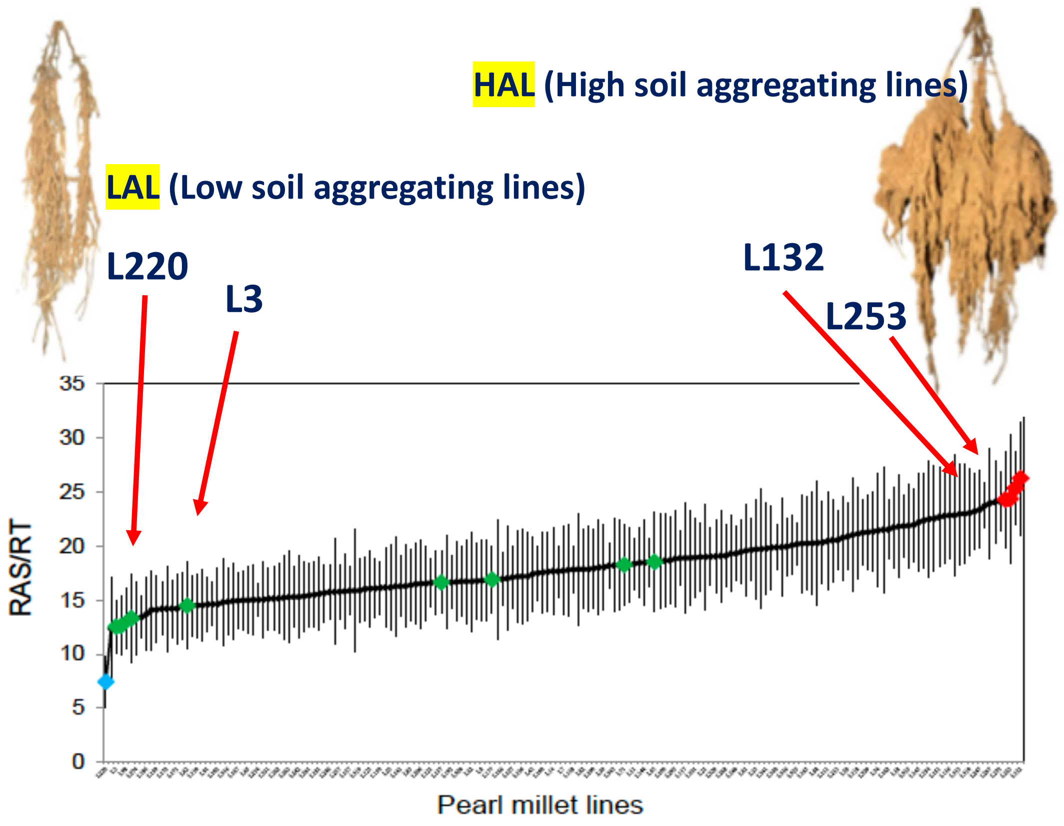
Root traits for adaptation of pearl millet to future climate in West Africa



ANR
RootAdapt

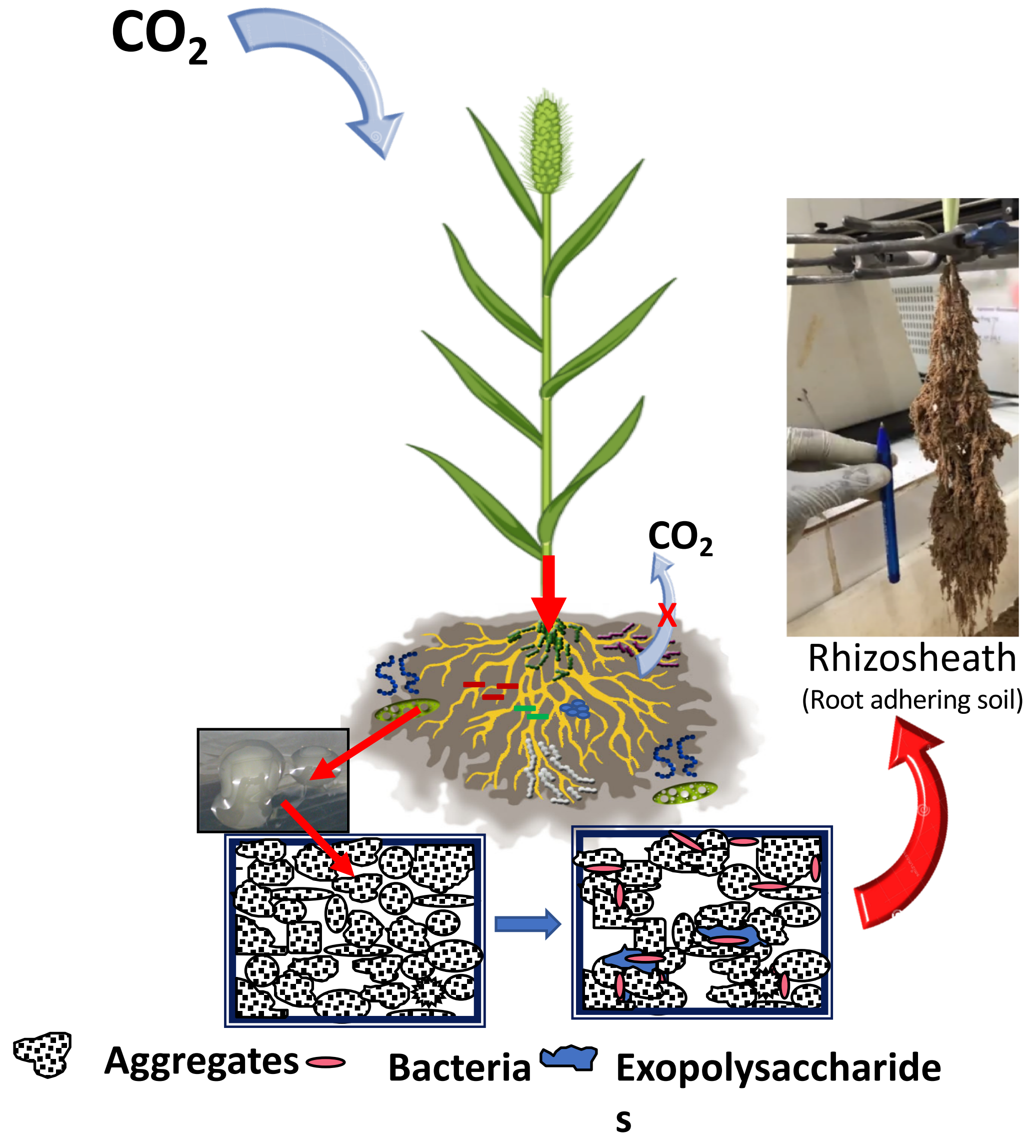
>180 pearl millet inbred lines have been screened:

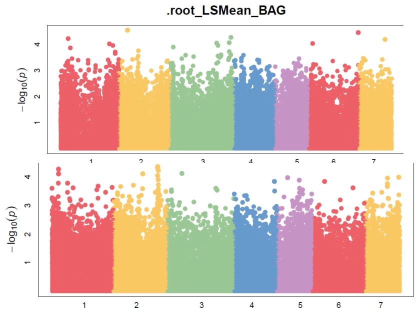
Root Architecture/Soil structuration



Objectives: Is there any correlation between rhizosheath size, **rhizodeposition**, root exudates composition, microbial community assemblage and carbon storage in soil ?

Root traits for adaptation of pearl millet to future climate in West Africa

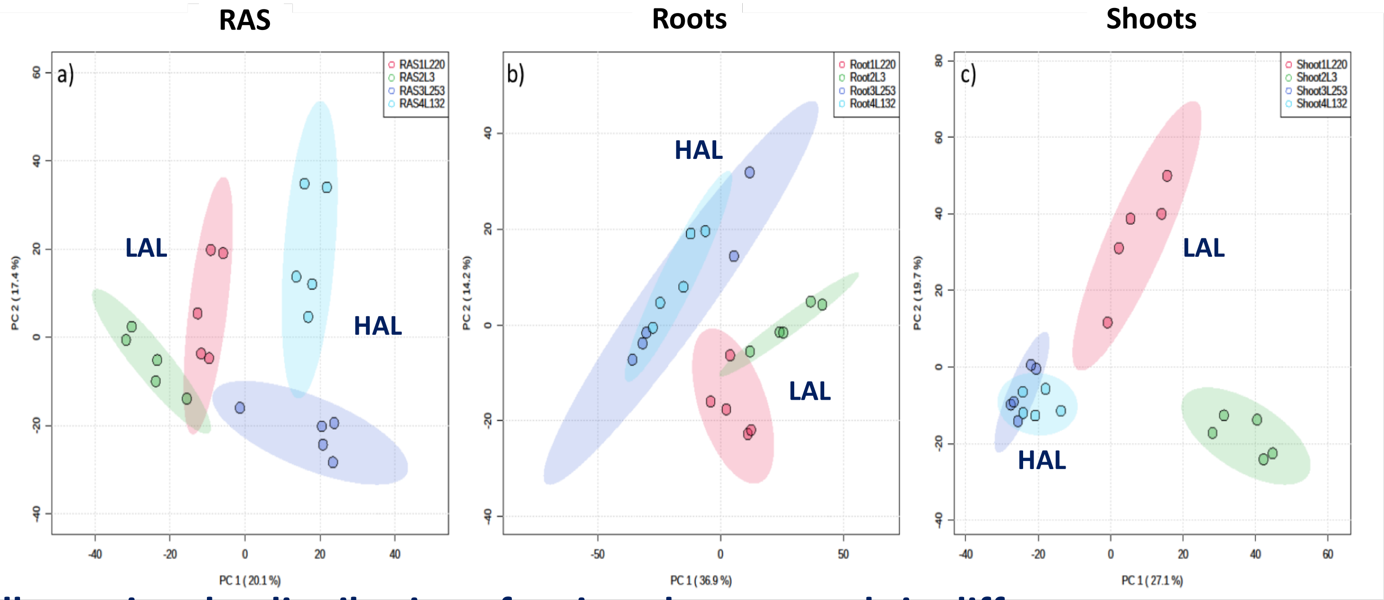




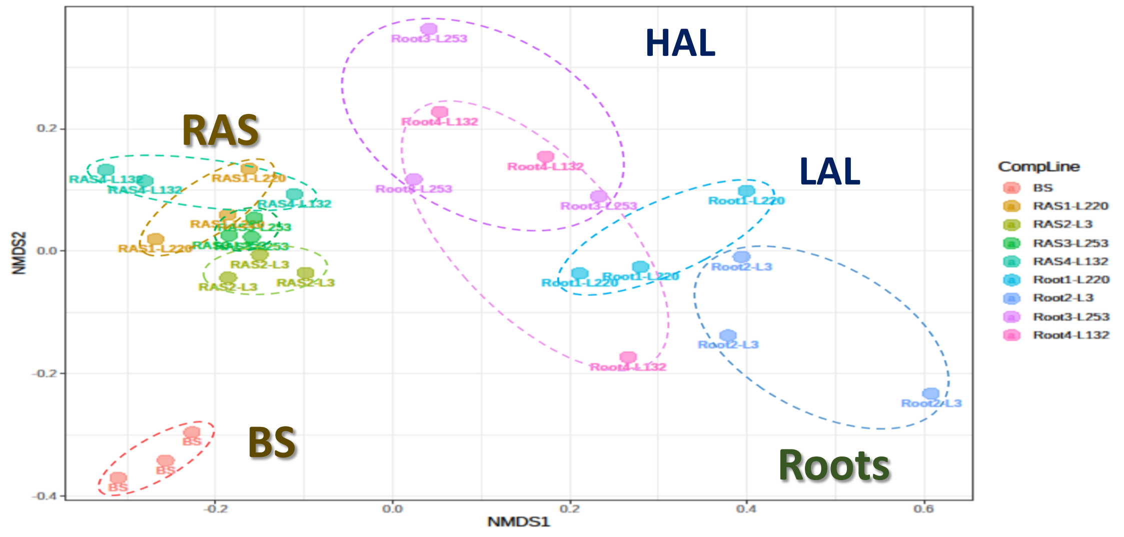
The root exudation of millet evaluated by a simple phenotype to measure (**root-adhering soil**, SAR) is genetically controlled, thus paving the way for varietal selection. (De la Fuente et al., Sc. Rep. 2022)

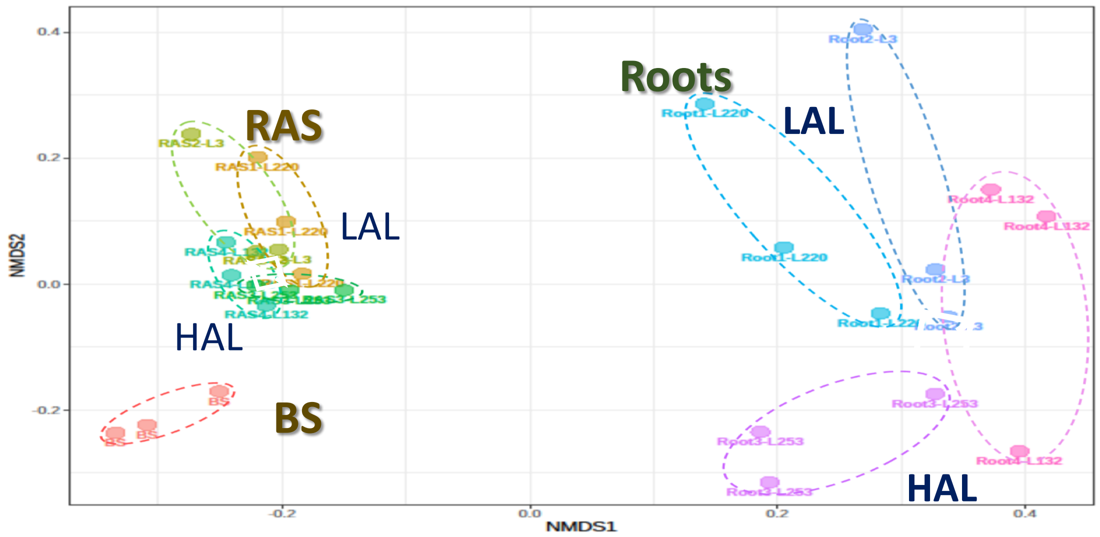
Interplay Between Root Exudates, Microbiota, and Rhizosheath Formation in Pearl Millet

Alahmad *et al.*, Microbiome, 2024



PCA 2D scores plots illustrating the distribution of assigned compounds in different compartments of each PM line.

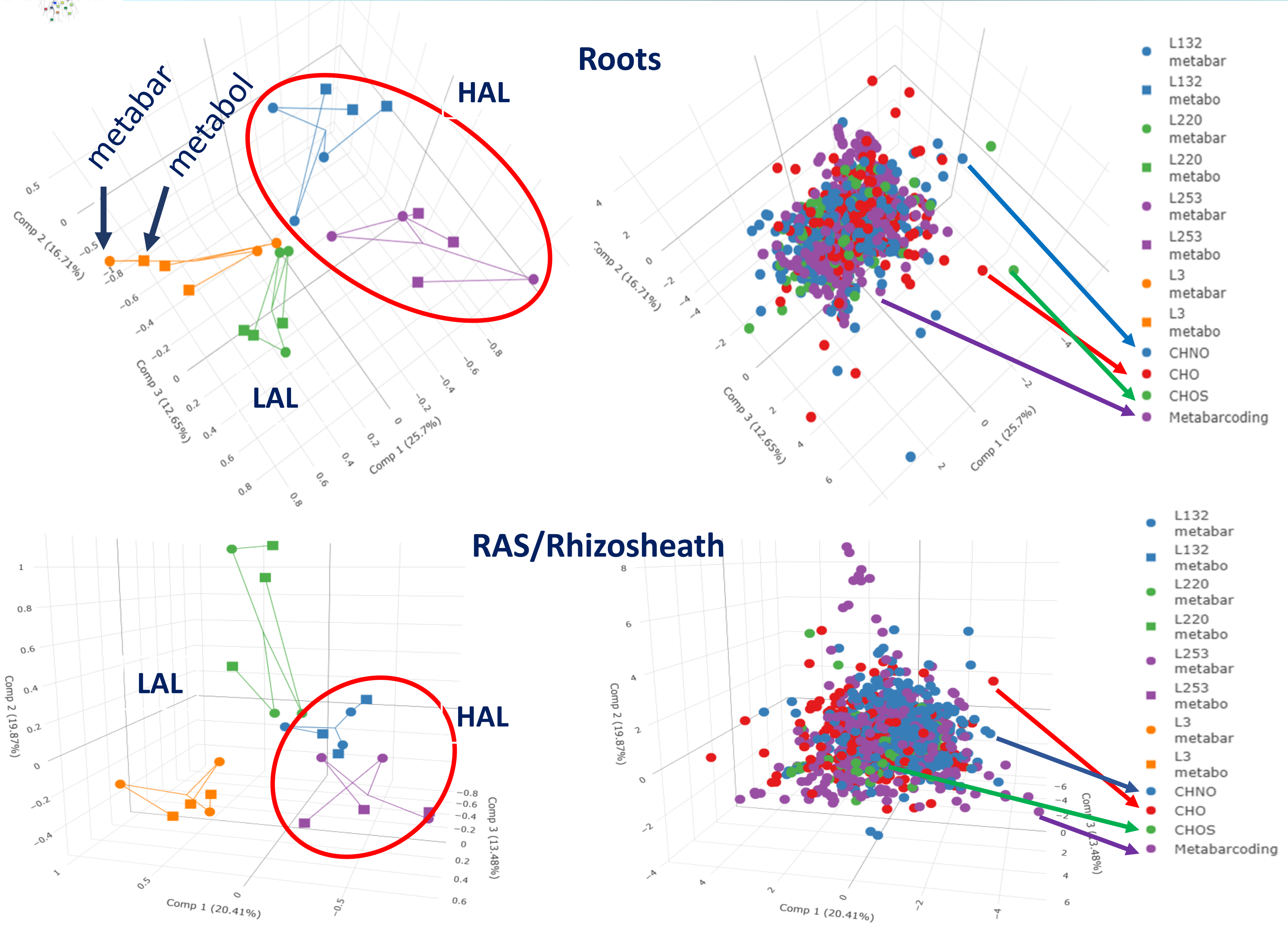




NMDS plots of the beta-diversity of bacterial communities

NMDS plots of the beta-diversity of fungal communities

Interplay Between Root Exudates, Microbiota, and Rhizosheath Formation in Pearl Millet



3D plot of Co-inertia analysis (CIA) of metabarcoding (circular) and metabolomics (square) data sets in the root & RAS of the four PM lines where the lines relates the position of the samples in the metabarcoding dataset in relation to the metabolomics one.

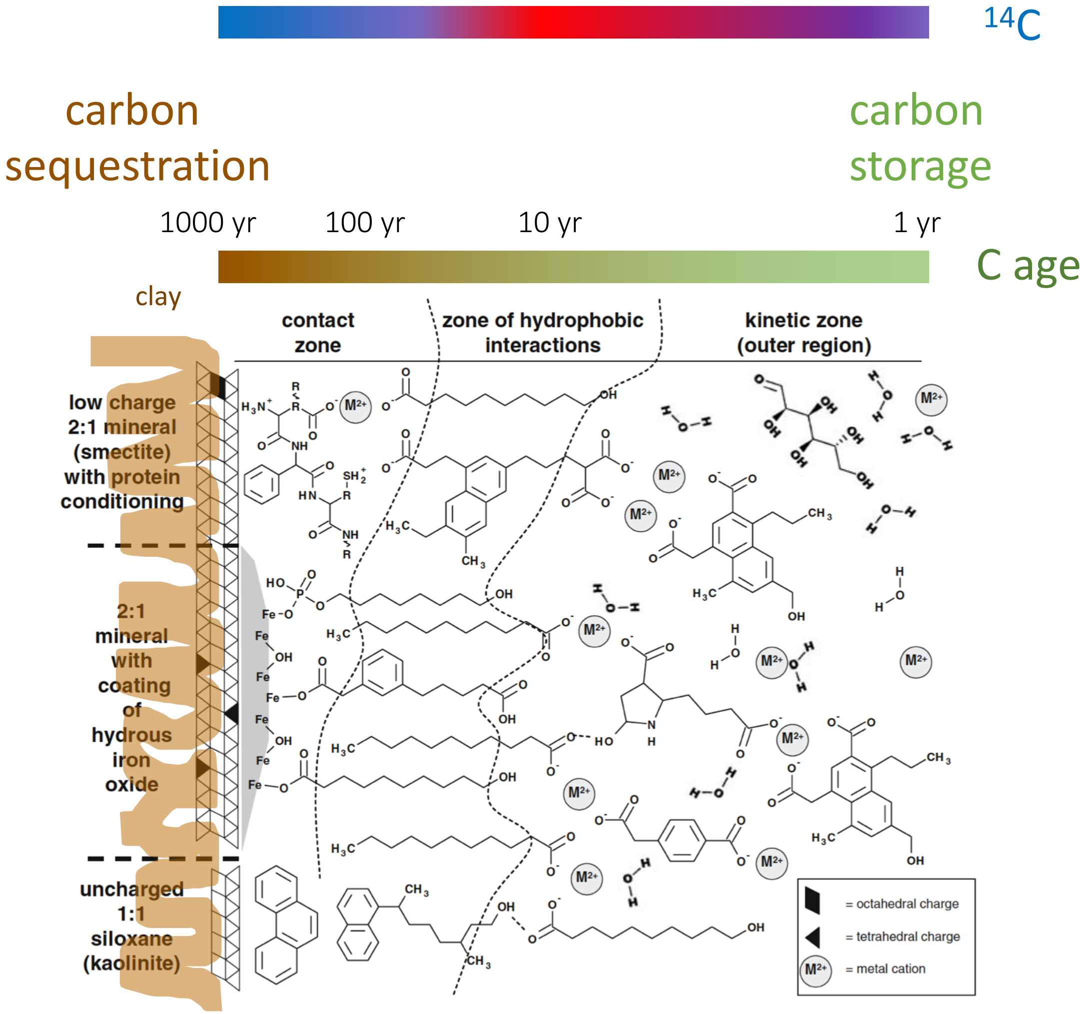
- The rhizosheath formation is under complex genetic control in pearl millet and suggests that it is mainly regulated by root exudation/rhizodepostion (de La Fuente *et al.,* 2022).

- The root-adhering soil mass is a heritable trait in pearl millet that correlates with changes in rhizosphere microbiota structure and functions, and root exudates composition (Alahmad *et al*, 2024).

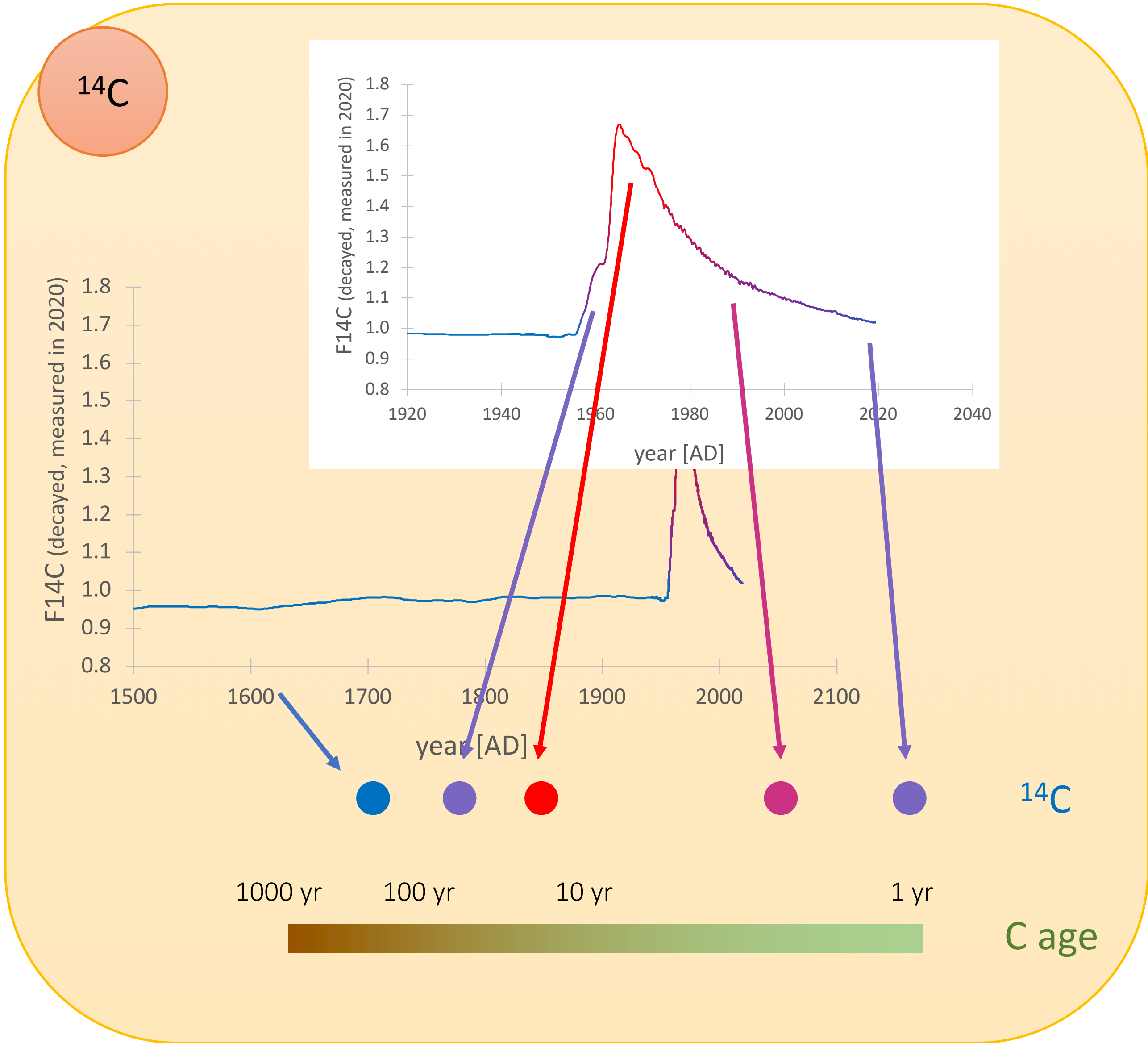
- The priming effect amplitude (C_{lost}/C_{new} ratio) was higher for the LAL than for the HAL, indicating a better C sequestration potential of the latter (Ndour *et al*., 2022).

Evaluation of agronomical practices
contribution of isotopic measurements

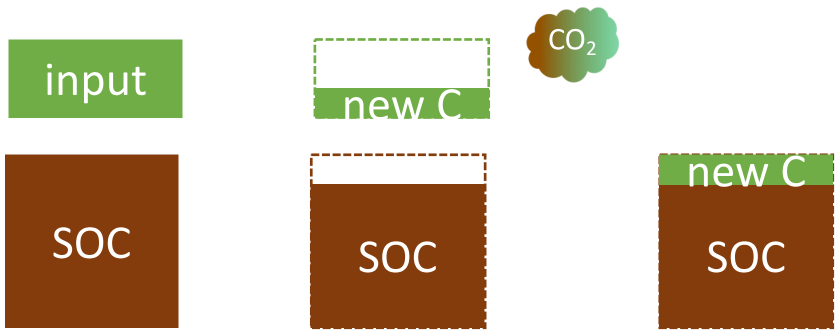
carbon storage – carbon sequestration



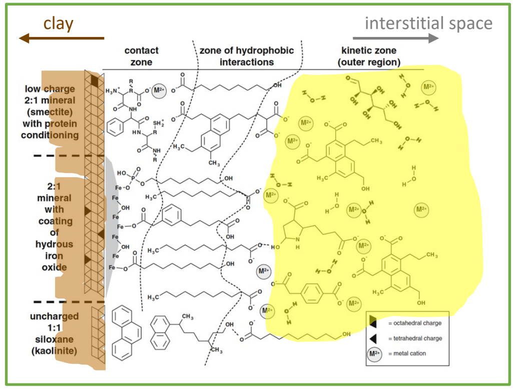
Kleber et al. 2007



heterotrophic respiration - priming effect

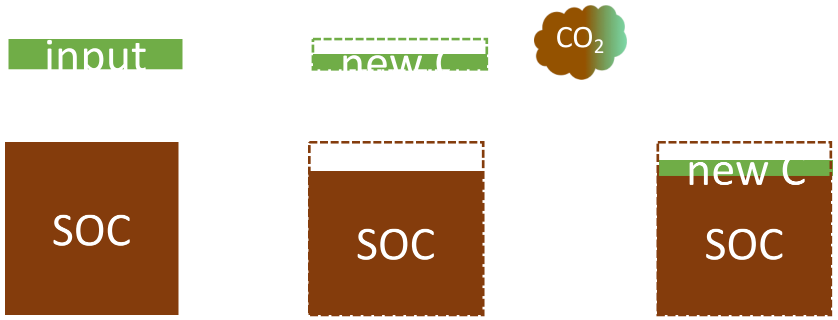


stable SOC

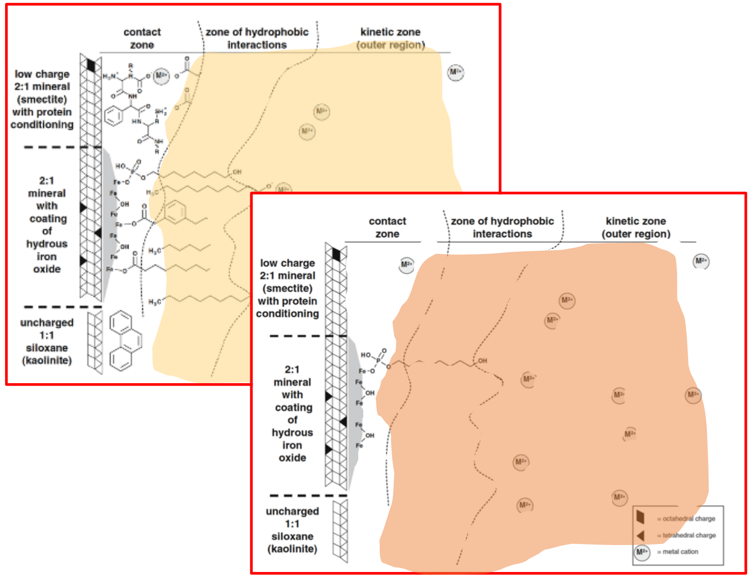


steady-state

- exchanges in the kinetic zone



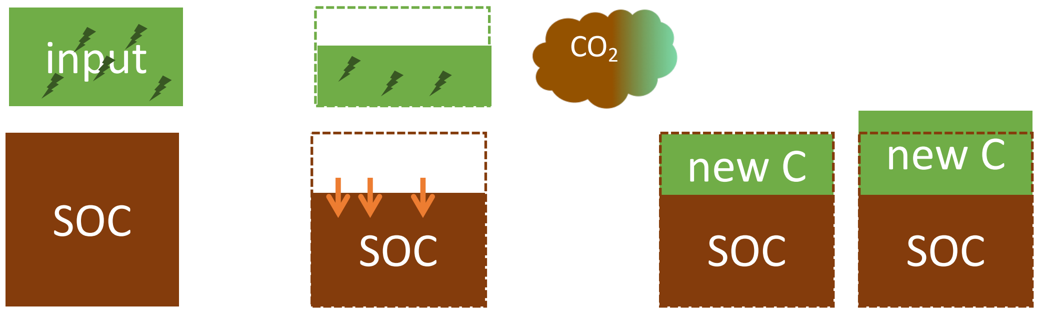
decreasing SOC



deleterious practices

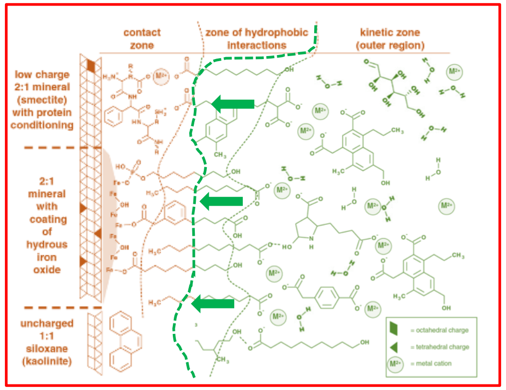
- hydrophobic/contact zones affected

heterotrophic respiration - priming effect



stable or increasing SOC

good (?) idea



enhancement of priming effect

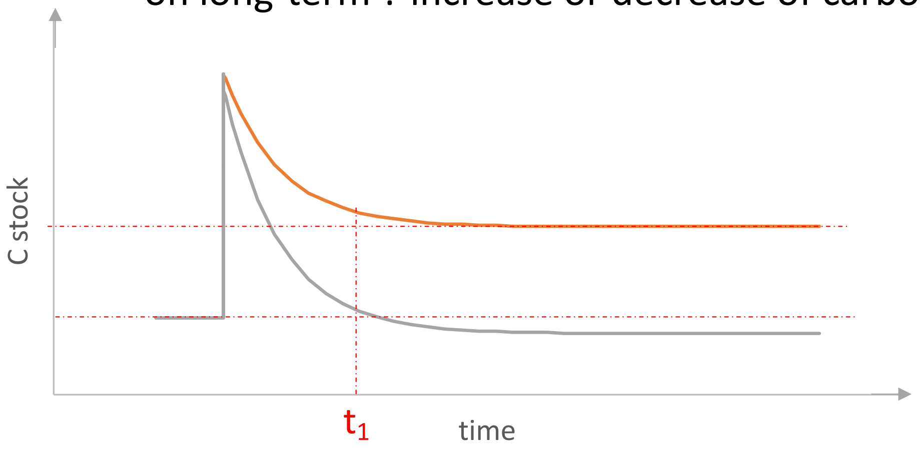
change in molecular cortege

- shrinking of hydrophobic zone
- enlargement of the kinetic zone

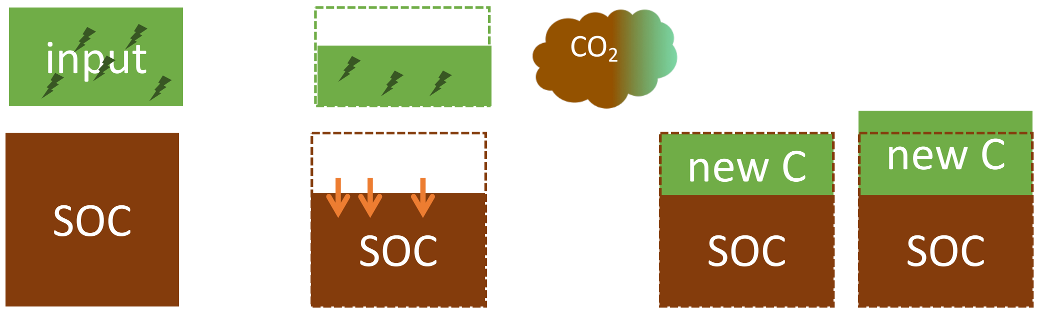
=> less sequestrated carbon

=> more molecule with short turnover time

on long-term ? increase or decrease of carbon stock?



priming effect – how to assess it ?



stable or increasing SOC

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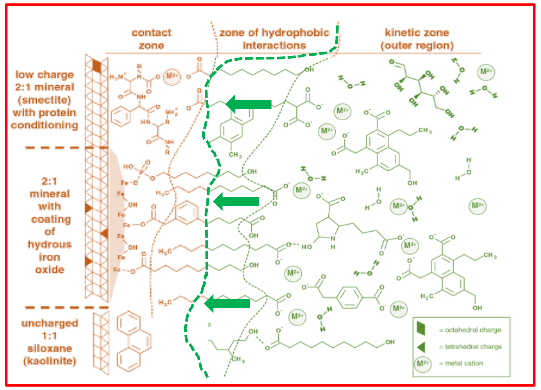

enhancement of priming effect

change in molecular cortege

- shrinking of hydrophobic zone
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=> less sequestrated carbon

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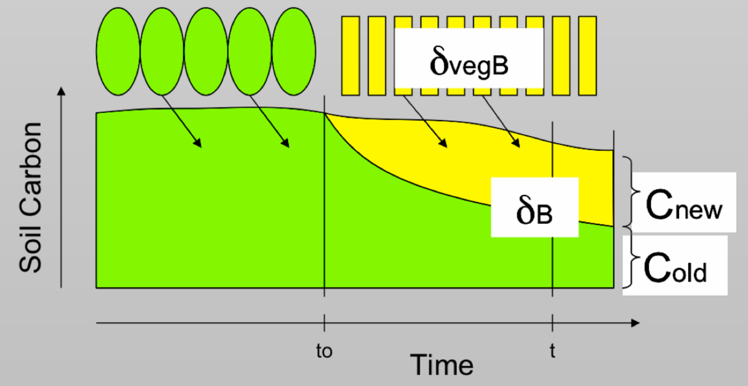
^{13}C

^{15}N

stable isotopes - natural labelling (^{13}C & ^{15}N)

(Balesdent's approach)

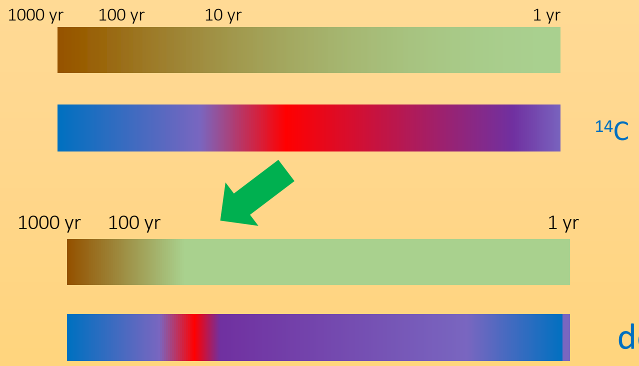


^{14}C

^{14}C informs on nature of the lost carbon

reminder @ t = 0

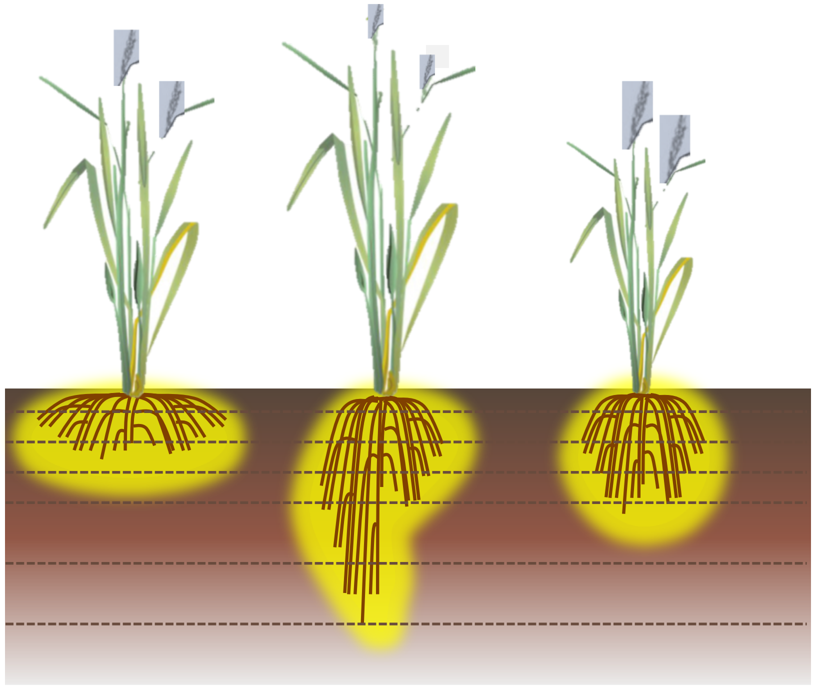
t

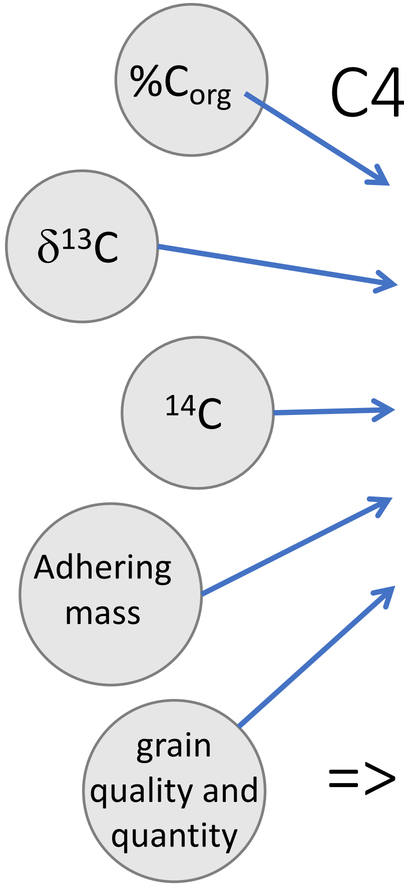


decrease of ^{14}C

Assessment – a case study

An evaluation of new agronomical practices





C4 plants in C3 soil

- Carbon stock evaluation
- ratio of new C
- contribution to "priming effect"
- drought resistance
- yield

=> Which practice for which result?

Assessment – a case study

An evaluation of new agronomical practices

L3 (intermédiaire)

+ C_{new} = 0.019 %wt

-- C_{lost} = 0.066 %wt

$\int F^{14}C_{lost} = 1.21$

C_{new} = -0.018 %wt

L132 (hyper)

C_{new} = 0.013 %wt -

C_{lost} = 0.038 %wt +

$\int F^{14}C_{lost} = 1.26$

C_{new} = -0.010 %wt

=> L132 is a good "4‰" candidate : it contributes to C input while keeping reduced loss of C

=> ATTENTION to *priming effect* ! : L3 destores more C than it brings in

Sitor et al. 2022

priming effect @ LSCE

^{13}C ^{15}N

EA/GC – IRMS (Delta+ XP)
bulk and specific compound

^{14}C

ECHoMICADAS
(few µg of C)

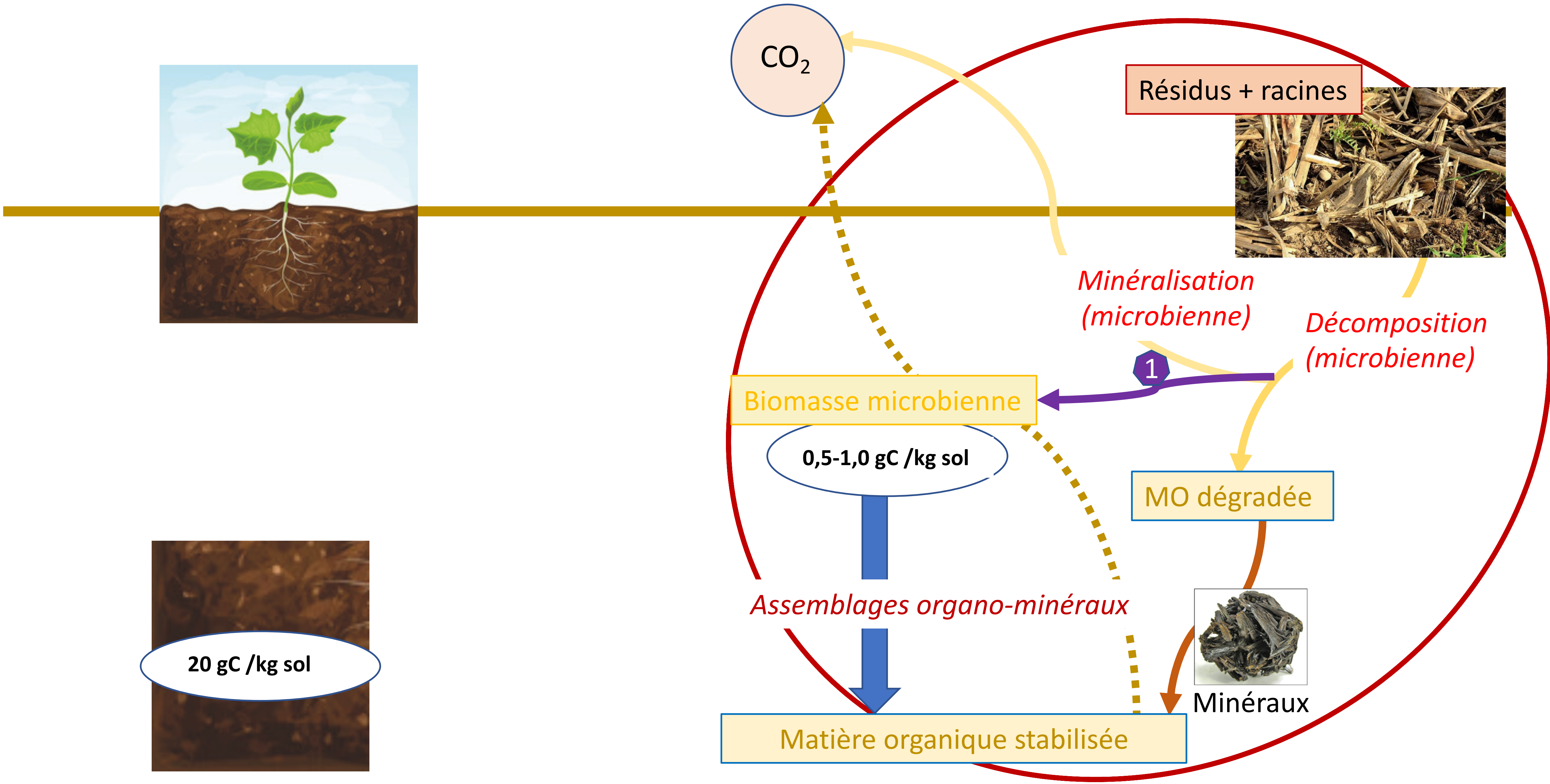
EA

GC

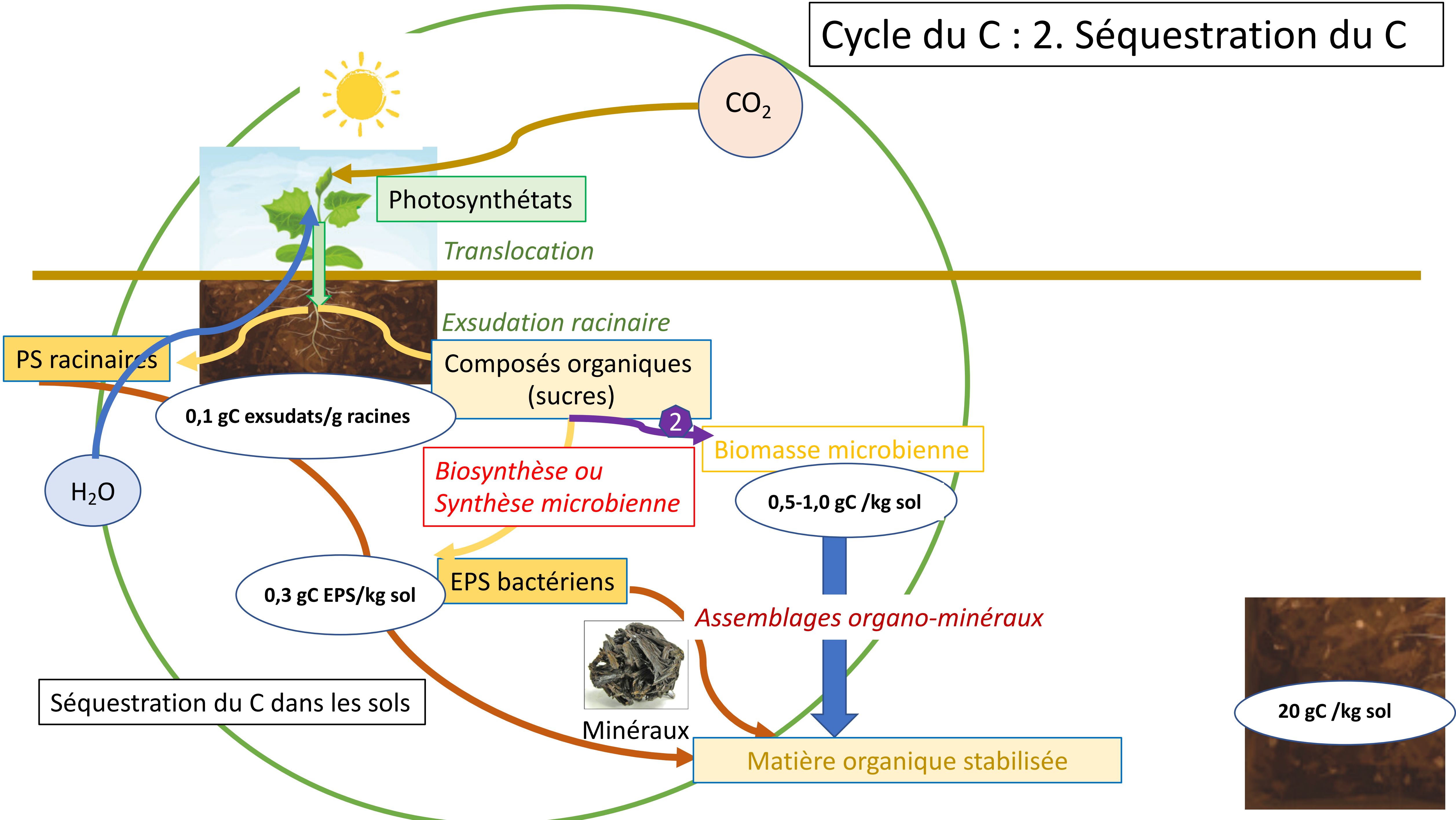
Balesdent et al. 2017, 2018
Camino-Serrano et al. 2019
Jreich et al. 2018, 2021
Kheirbeik et al. 2016
Lawrence et al. 2020
Mathieu et al. 2015
Mendez-Millan et al. 2013
Ndour et al. 2022
Paul et al. 2016, 2019
Quéro et al. 2022
Rubino et al . 2014
Tifafi et al. 2018a, 2018b

Conclusion-Perspectives

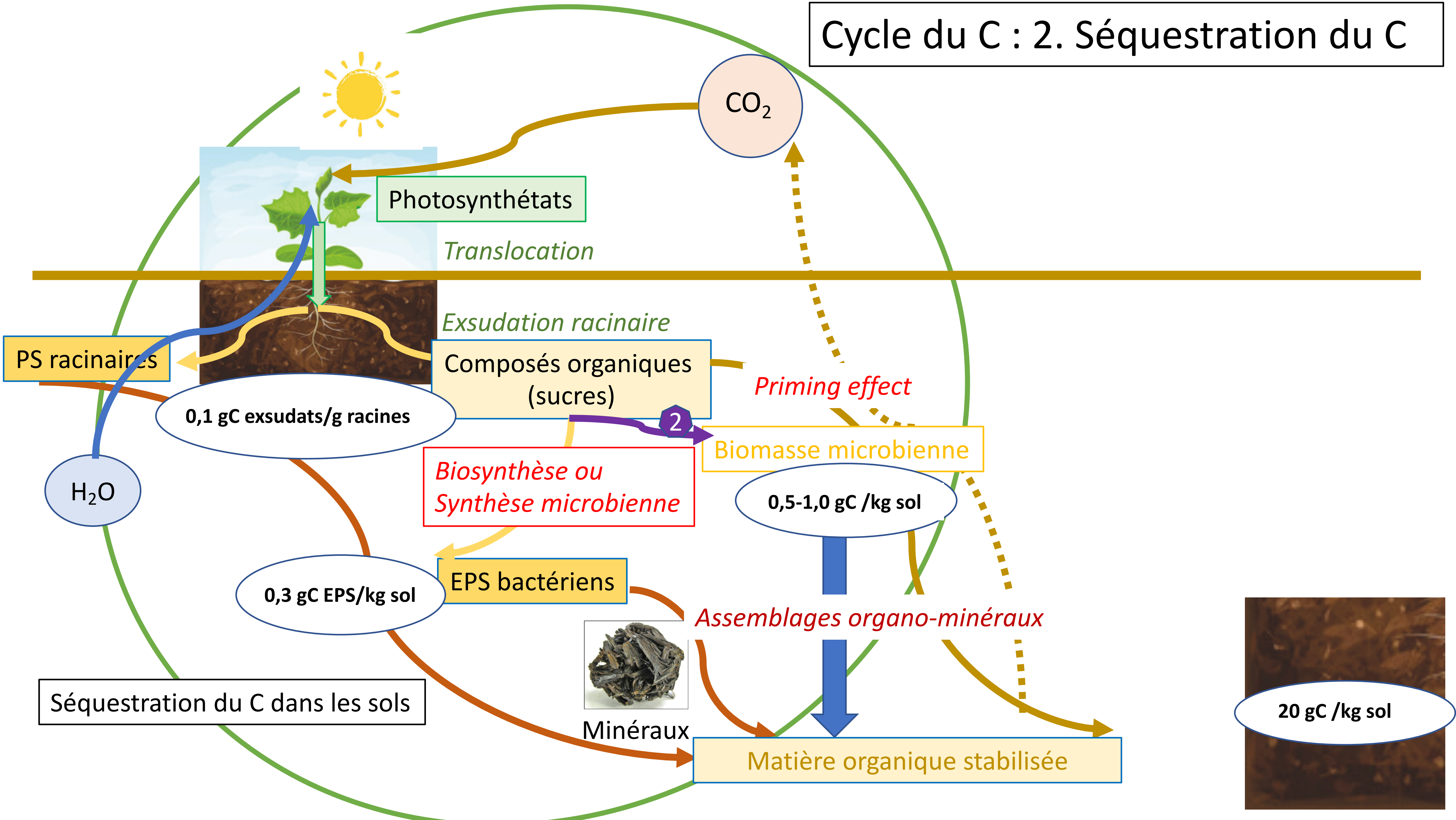
Cycle du C : 1. Stockage du C



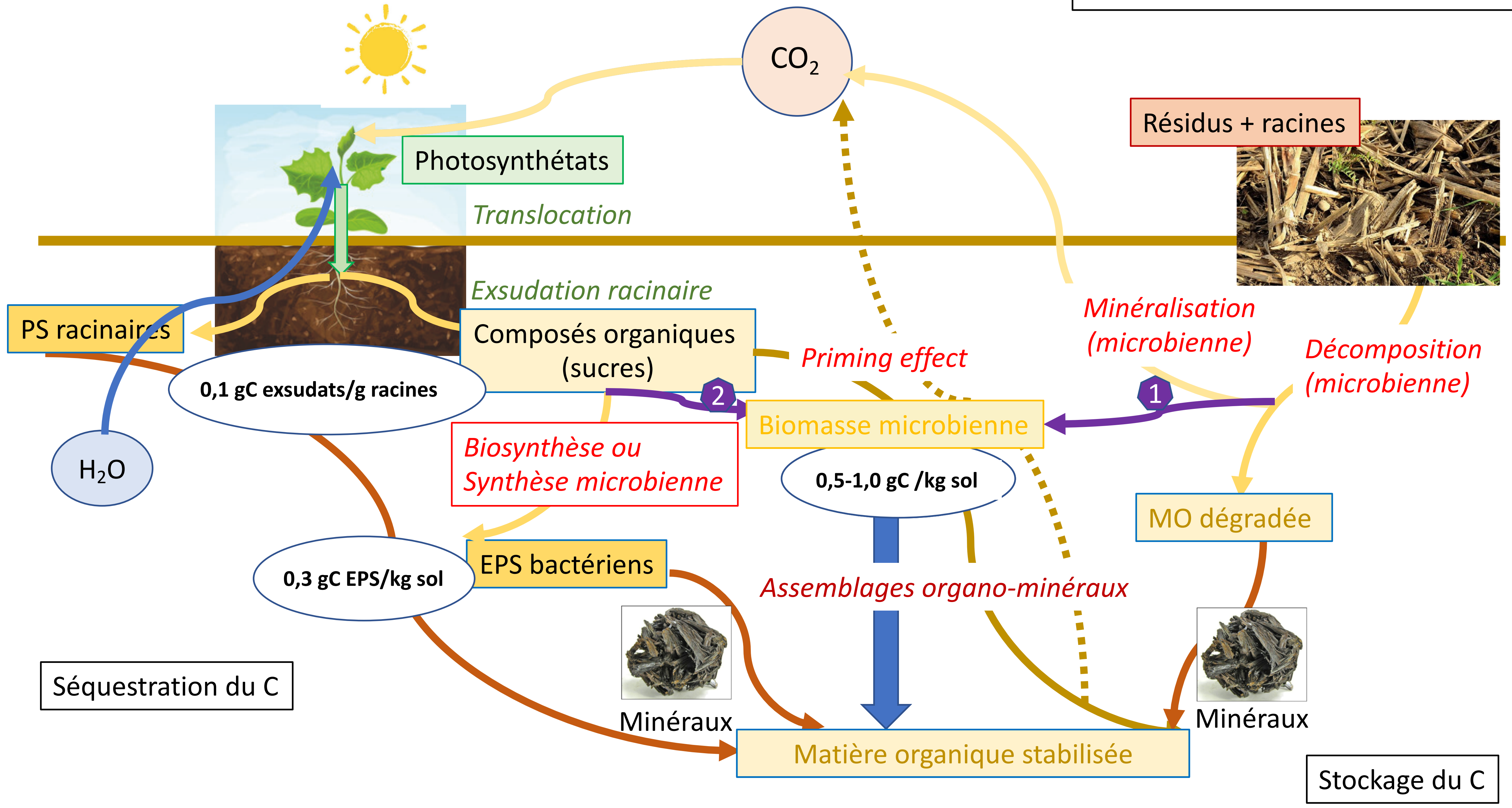
Cycle du C : 2. Séquestration du C



Cycle du C : 2. Séquestration du C



Cycle du C dans les sols



Article

Microbial carbon use efficiency promotes global soil carbon storage

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Feng Tao[1,2,3], Yuanyuan Huang[4], Bruce A. Hungate[5,6], Stefano Manzoni[7], Serita D. Frey[8], Michael W. I. Schmidt[9], Markus Reichstein[2], Nuno Carvalhais[2,10], Philippe Ciais[11], Lifen Jiang[12], Johannes Lehmann[13], Ying-Ping Wang[14], Benjamin Z. Houlton[15], Bernhard Ahrens[2], Umakant Mishra[16,17], Gustaf Hugelius[7], Toby D. Hocking[6], Xingjie Lu[18], Zheng Shi[19], Kostiantyn Viatkin[3,13], Ronald Vargas[3], Yusuf Yigini[3], Christian Omuto[3], Ashish A. Malik[20], Guillermo Peralta[3], Rosa Cuevas-Corona[3], Luciano E. Di Paolo[3], Isabel Luotto[3], Cuijuan Liao[1], Yi-Shuang Liang[1], Vinisa S. Saynes[3], Xiaomeng Huang[1]✉ & Yiqi Luo[12]✉

Nature Com (2021)

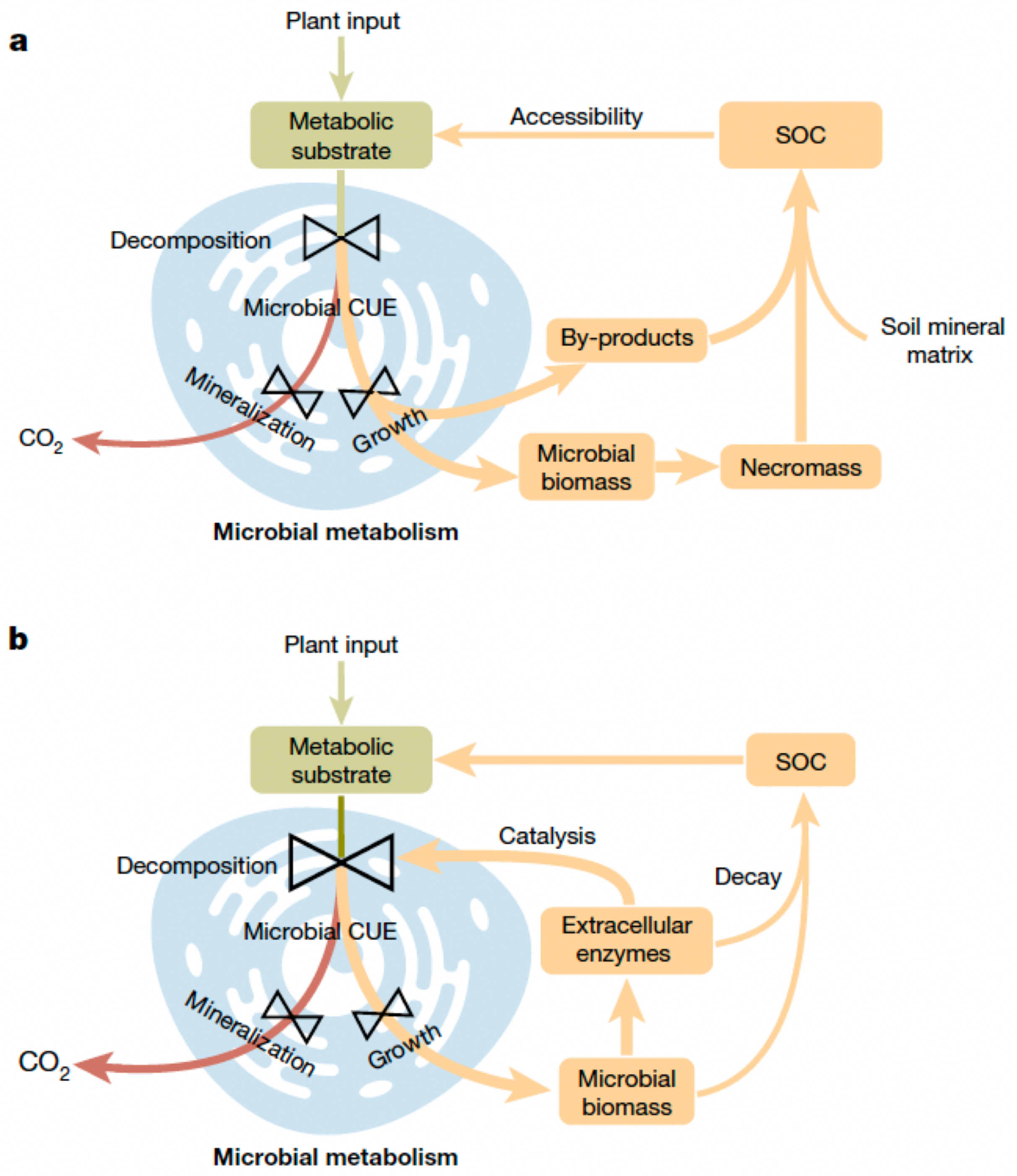
Microbial carbon use efficiency promotes global soil carbon storage

Nature Com 2023
https://doi.org/10.1038/s41586-023-06042-3

Two contrasting pathways in determining the relationship between microbial CUE and SOC storage.

a**, The first pathway** indicates that a **high CUE favours the accumulation of SOC storage** through increased **microbial biomass** and **by-products**.

b, **The second pathway** emphasizes that a **high CUE stimulates SOC losses** via increased microbial biomass and subsequent **extracellular enzyme production** that enhances SOC decomposition



Microbial carbon use efficiency promotes global soil carbon storage

They find that **CUE** is at least **four times as important as other evaluated factors**, such as carbon input, decomposition or vertical transport, in determining SOC storage and its spatial variation across the globe. In addition, **CUE shows a positive correlation with SOC content**. Our findings point to microbial CUE as a **major determinant of global SOC storage**. Understanding the microbial processes underlying CUE and their environmental dependence may help the prediction of SOC feedback to a changing climate.

Merci pour votre attention