The priming effect: a point of connection between microbial ecology, C cycling and plant functioning

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Context

- There is an increasing body of evidence that soil organic carbon (SOC) decomposition is limited by the size of microbial populations:
  - Only 2-3% of SOC compounds is colonized by microbes.
  - The stimulation of microbes by the supply of fresh C accelerates SOC decomposition (Priming effect)

Paul & Clark 1989; Wu *et al* 1993; Schimel & Weintraub 2003; Fontaine *et al* 2004; Dijkstra & Cheng 2007 but see also Kemmitt *et al* 2008.

Context

- This limitation calls in question the equation that is in the heart of current models:

$$\frac{dC}{dt} = -kC$$

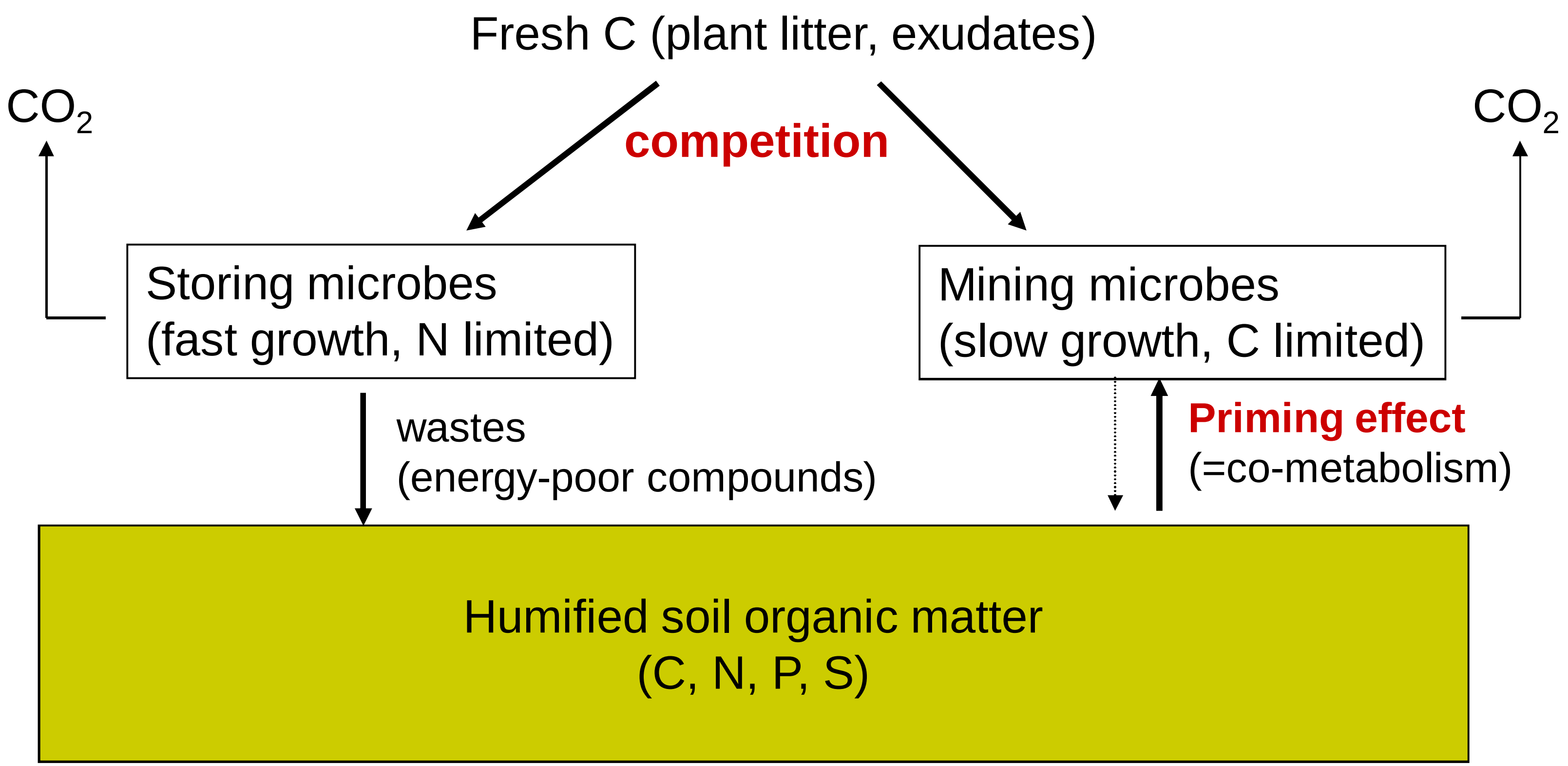
(Jenny, 1941)

Context

- Including microbial populations in models changes predictions:
  - Non-limited capacity of soil to accumulate SOC.
  - **The storage of SOC in soils would depend on the competition between two microbial functional groups.**

Fontaine et al., Ecol Lett (2005)

Alternative theory of SOC dynamics



Fontaine et al., Ecol Lett (2005)
Fontaine et al., Nature (2007)

Objectives

- The objectives of this study were:
  - identifying the microbial populations involved in the priming and,
  - testing the theory of ñthe competitionòby identifying different functions (storing/mining) among these populations.

An approach in two steps

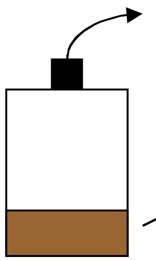
- **Experiment 1**: identifying the dominant microbial populations that occur during the priming effect.

Soil incubations

Fresh grassland soil (0-20 cm)

Soil alone (control) — Soil+cellulose (^{13}C)

water — water+NPK — water — water+NPK

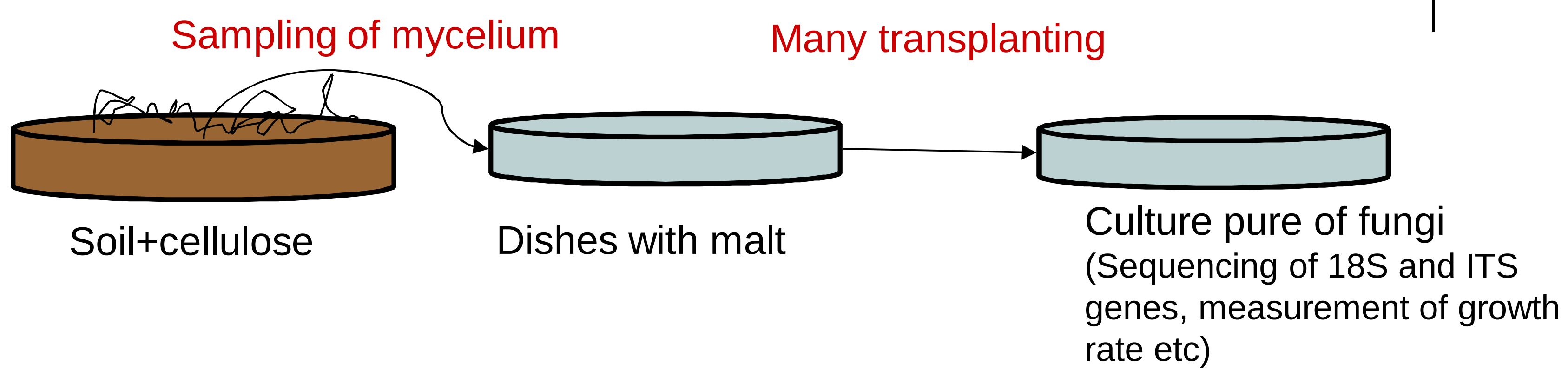


CO_2, ŭ ^{13}C (Priming measurement)

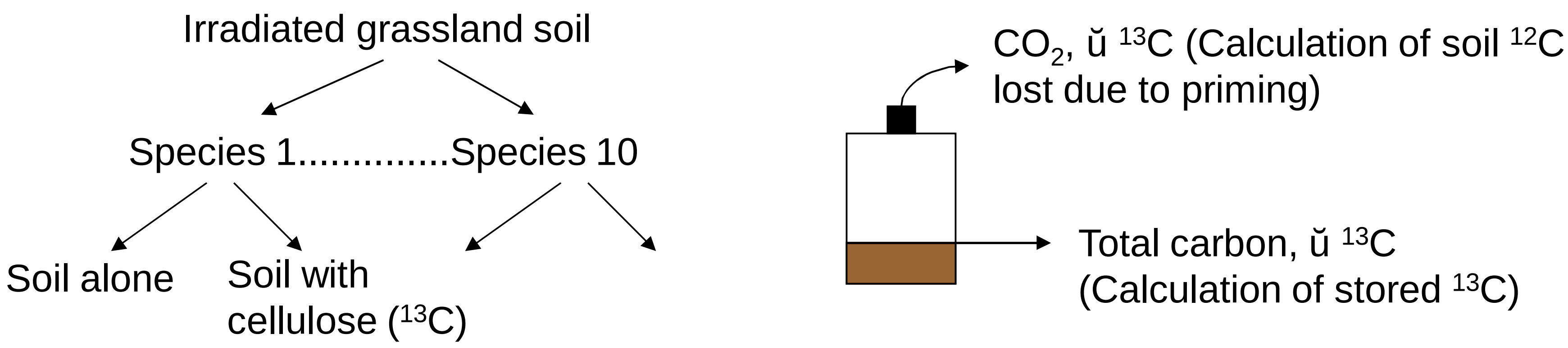
Microbial PLFA
Microbial DNA (B-ARISA and F-ARISA)
Molecular inventory of dominant fungi (cloning and sequencing of 18S rDNA of fungi)

- **Experiment 2**: who does what?

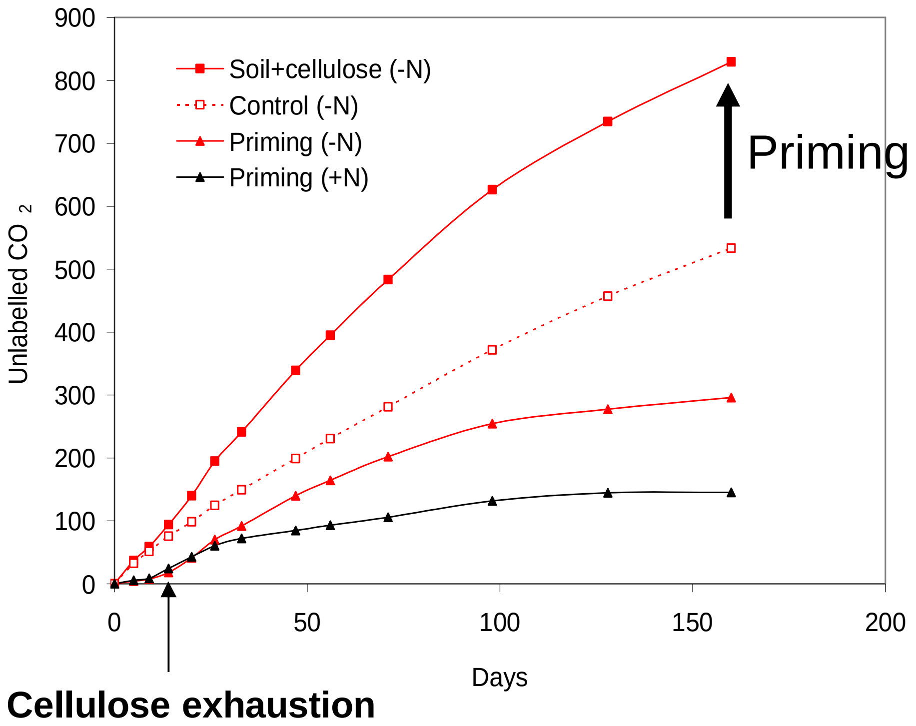
<u>a/ Isolation and identification of cellulolytic fungi</u>



<u>b/ Re-inoculation of fungi to determine their role on SOC (storing/mining).</u>



The supply of cellulose induced a ñpriming effectò



- ✓ **Cellulose decomposers mine SOC.**
- ✓ **This mining is 2 times higher in the low N treatment.**

What is the effect of cellulose supply on soil C storage?

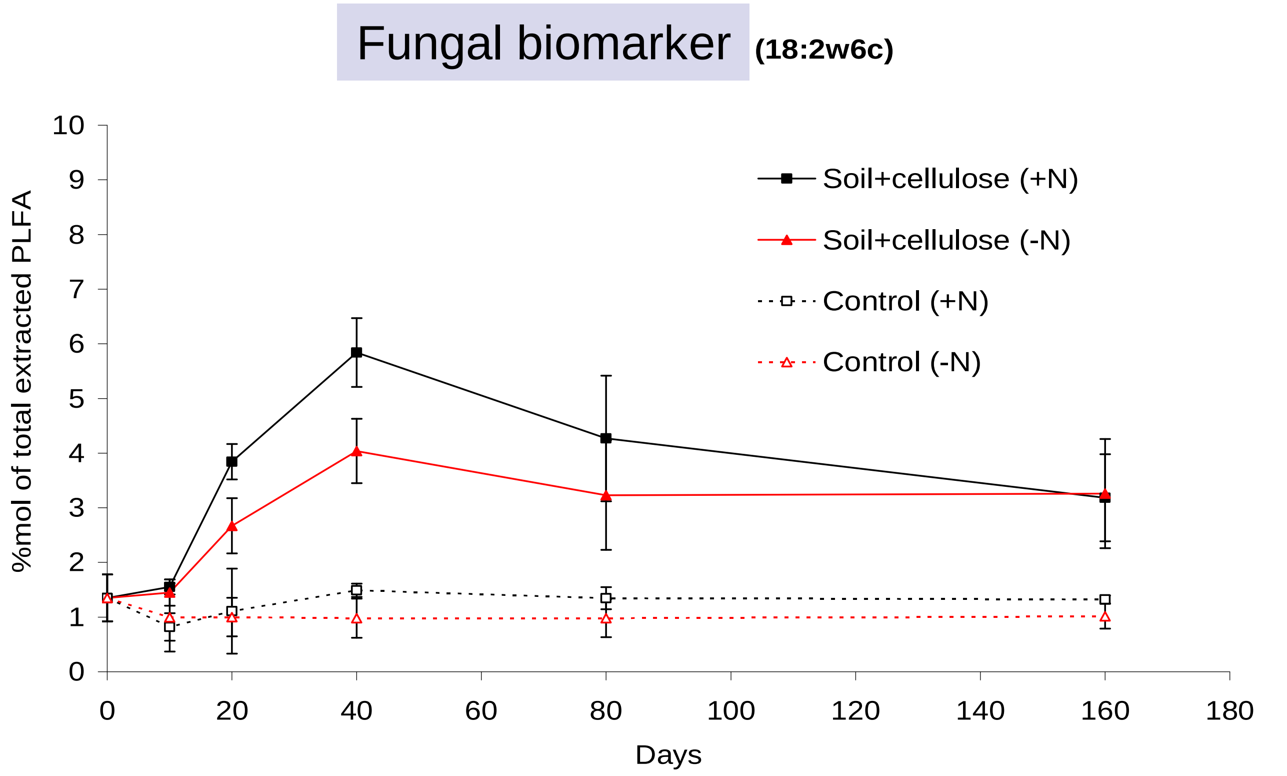
	Nitrogen treatments	
	High N	Low N
New soil C (^{13}C)	232 ± 17	235 ± 21
Old soil C (^{12}C) lost by the priming effect	145 ± 16	296 ± 9
Soil C balance	**+87**	**-61**

in mg C kg^{-1} after the addition of 1000 mg cellulose.

✓ **Carbon input to soil may decrease soil C content because of the priming effect.**

✓ **The availability of nitrogen controls the direction of soil C change.**

Analysis of microbial PLFA



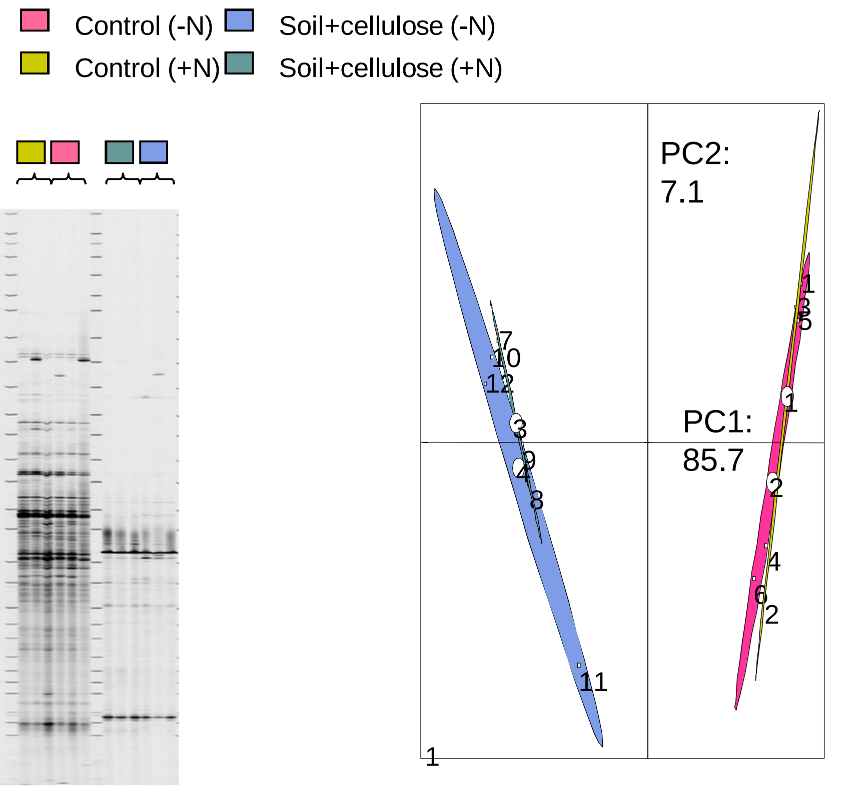
✓ **Fungi are key actors in the decomposition of cellulose and the induced priming.**

Results of the B- and F-ARISA

1./ The B-ARISA banding profiles were not affected by the supply of cellulose.

2./ The F-ARISA banding profiles were deeply affected by the supply of cellulose.

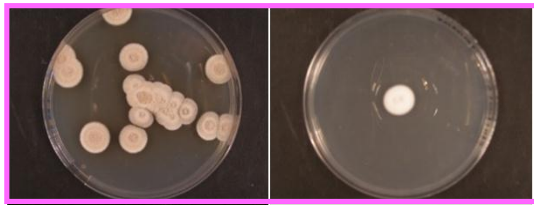
F-ARISA results for the day 40



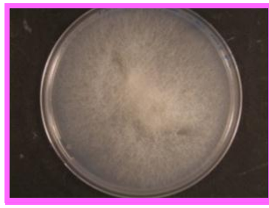
✓ This suggests that few different populations of fungi are involved in the priming.

✓The molecular inventory have identified two major populations : *Geomyces pannarum, Humicola fuscoatra* (data not shown).

Isolation of 17 strains (6 genus)

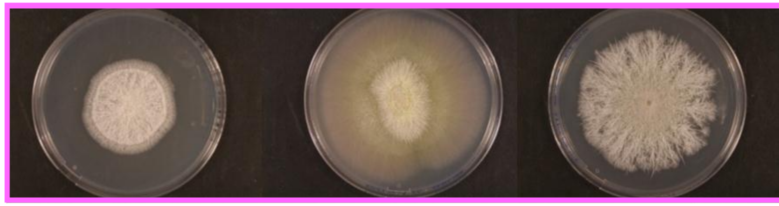


Geomyces pannorum

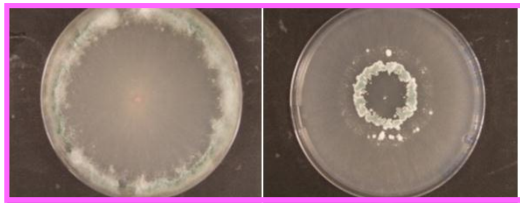


Mucor hiemalis

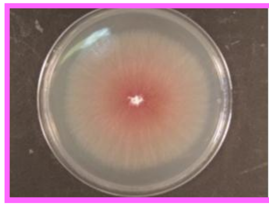
Humicola fuscoatra



Bionectria ochroleuca



Trichoderma sp



Fusarium oxysporum

Unknown species

Isolated species have contrasted growth rates, from 2 mm d^{-1} for *Humicola fuscoatra* to 12 mm d^{-1} for *Trichoderma sp.*

Who does what?

	Respired cellulose (% of total)	**Primed ^{12}C (mg C kg^{-1})**
Fusarium oxysporum	21 ± 0.2	**33 ± 11**
Bionectria ochroleuca	22 ± 1	**-3 ± 5**

Cellulose respiration and soil ^{12}C lost due to the priming after 16 days of incubation.

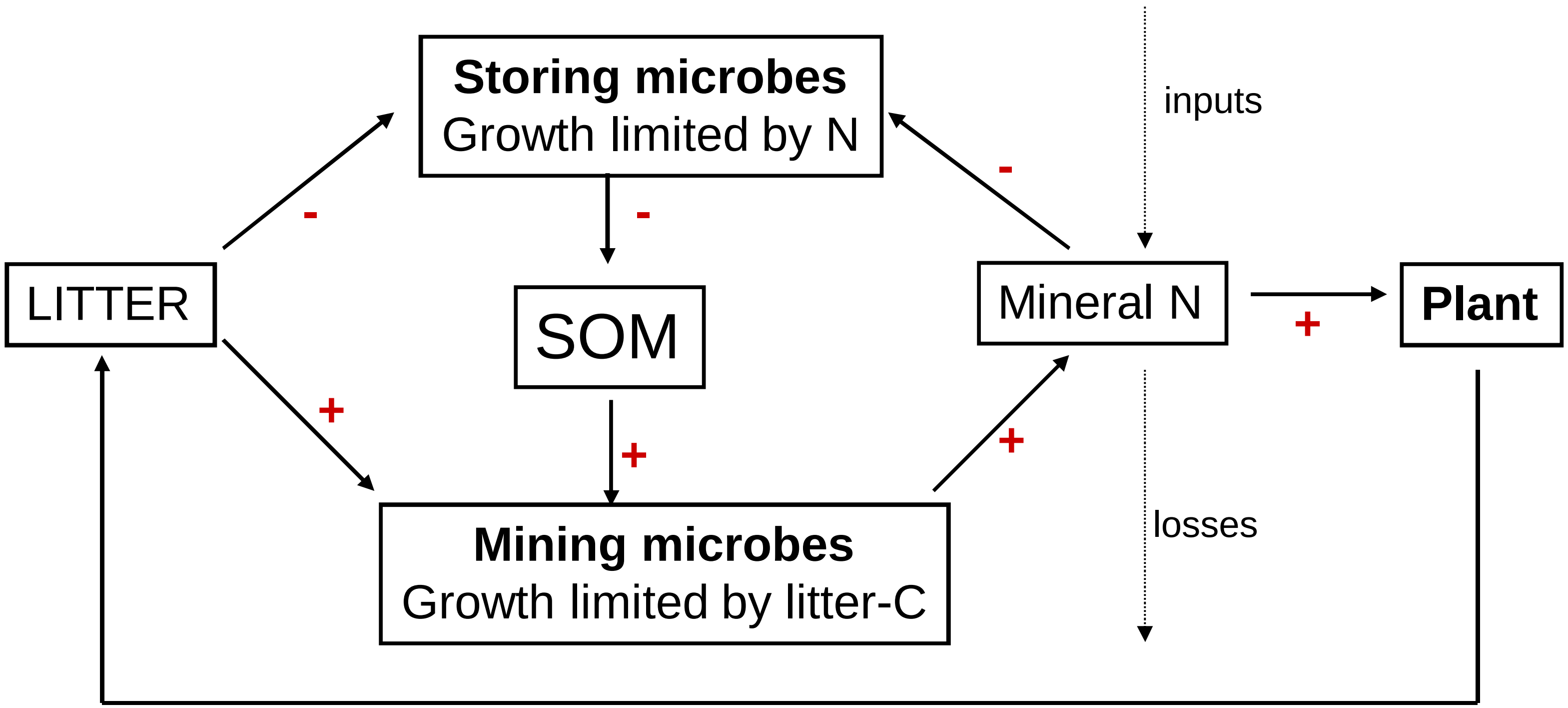
✓ These preliminary results supports the idea that some microbial species mine old SOC whereas others only stabilize the fresh C.

Conclusions & perspectives

- Carbon input to soil can increase or decrease soil C content.
- Fungi are key actors in the control of the priming effect.
- Preliminary results support the idea that two microbial functional types controls the sequestration of C in soil.
- Further experiments are needed to understand the impact of N availability on the priming effect.

Conclusions & perspectives

- Which connection with the plant functioning?

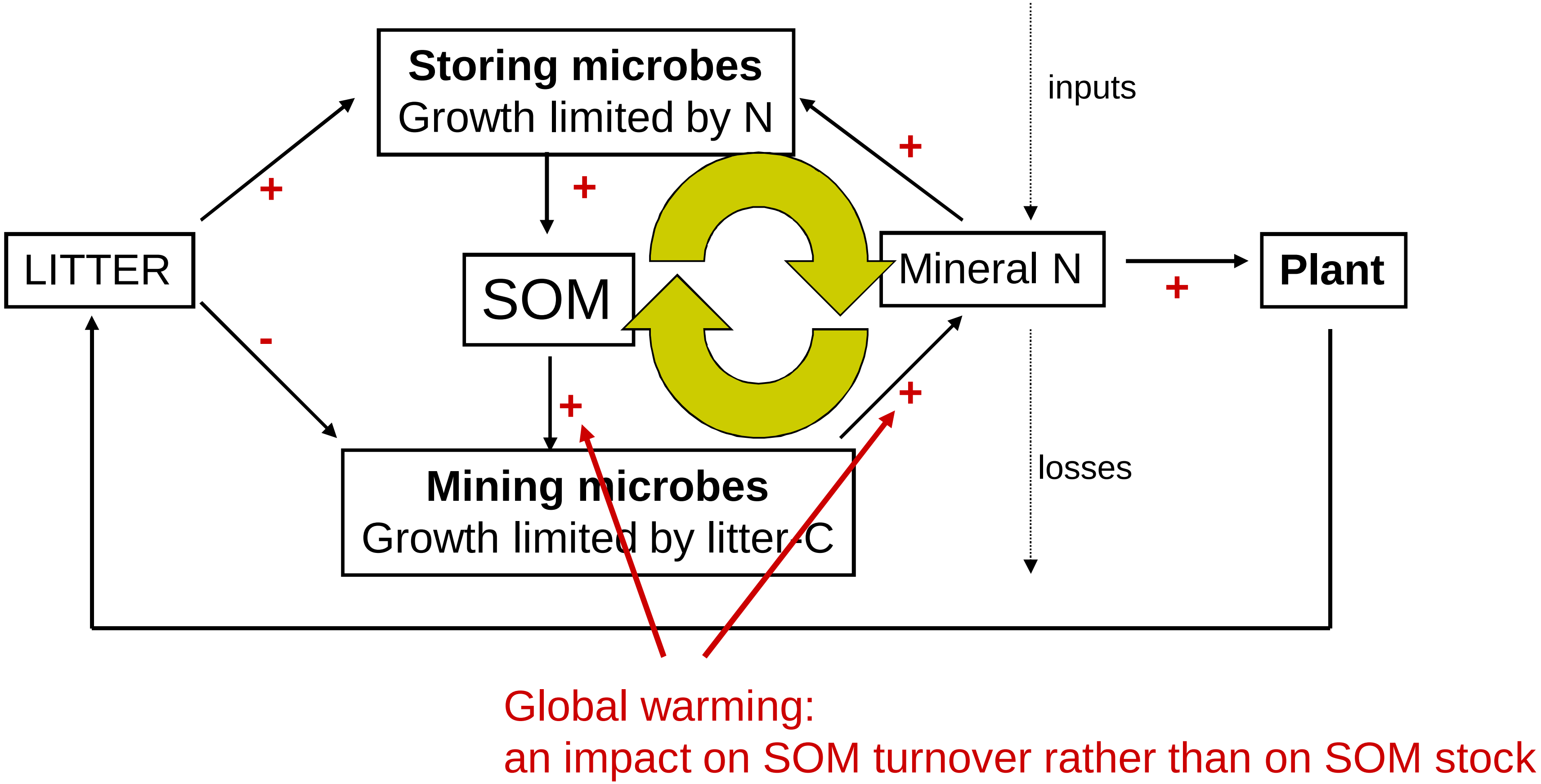


Fontaine et al., Ecol Lett (2005)

✓Plant would modulate the microbial competition and therefore the storing/mining of N in SOM by modifying the availability of mineral N.

Conclusions & perspectives

- Could the negative feedback between N availability and SOM mining limit global warming-induced loss of SOM?

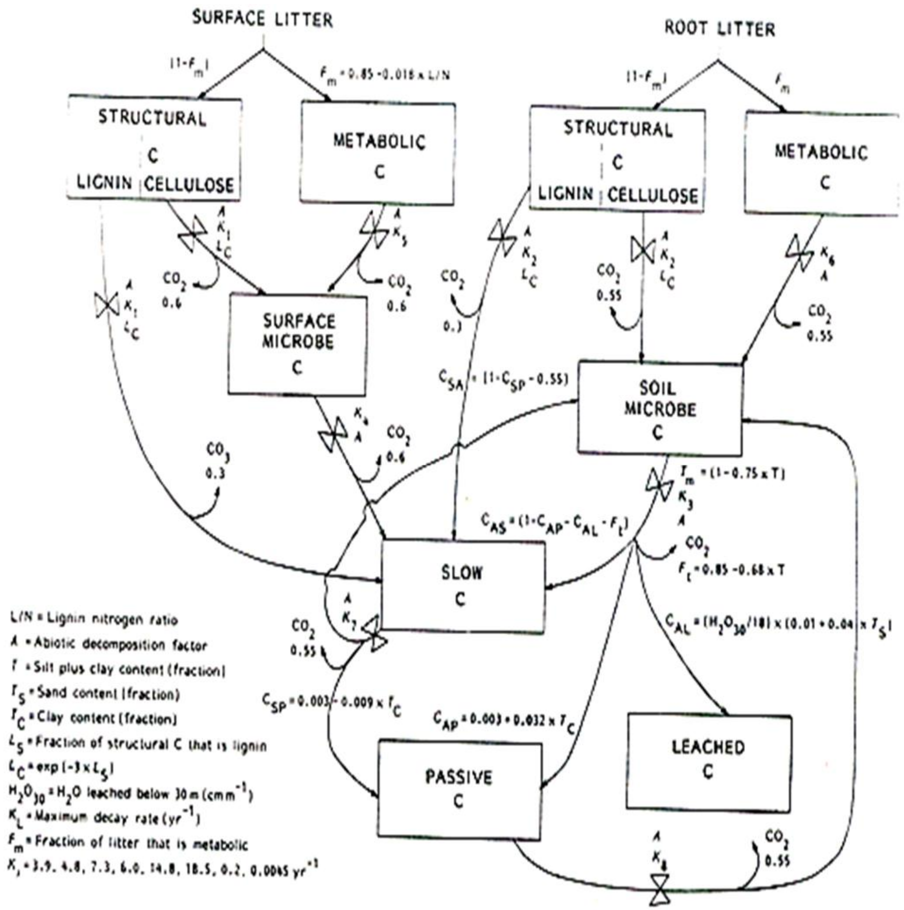


Thank you!

Co-authors of this study: Aamor, A., Henault, C., Maron, P-A, Mary, B., Oudin, A., Revaillot, S., Tardy, V.

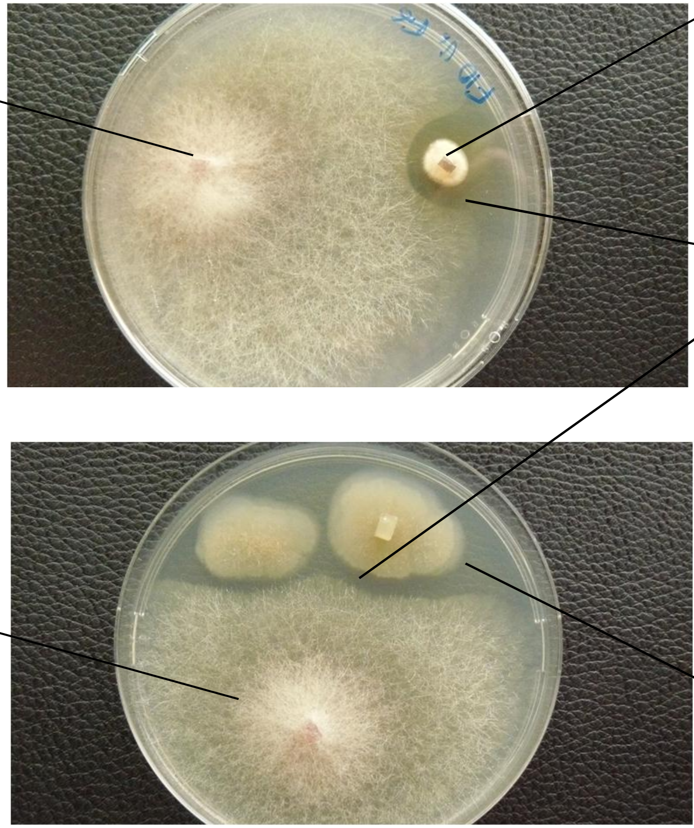
Is microbial ecology useful to predict soil C,N cycling in soils?

Decomposition process, modeled with dC/dt=kC, is assumed to be limited the quantity and the quality of C pool only.



An example of model: Century (Parton)

Microbial battles



Cultures on malt