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Biodiversity and rhizosphere process in plant/soil synchronization

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BASIL: Biodiversity and ecosystem services

Biodiversity and rhizosphere process in plant/soil synchronization

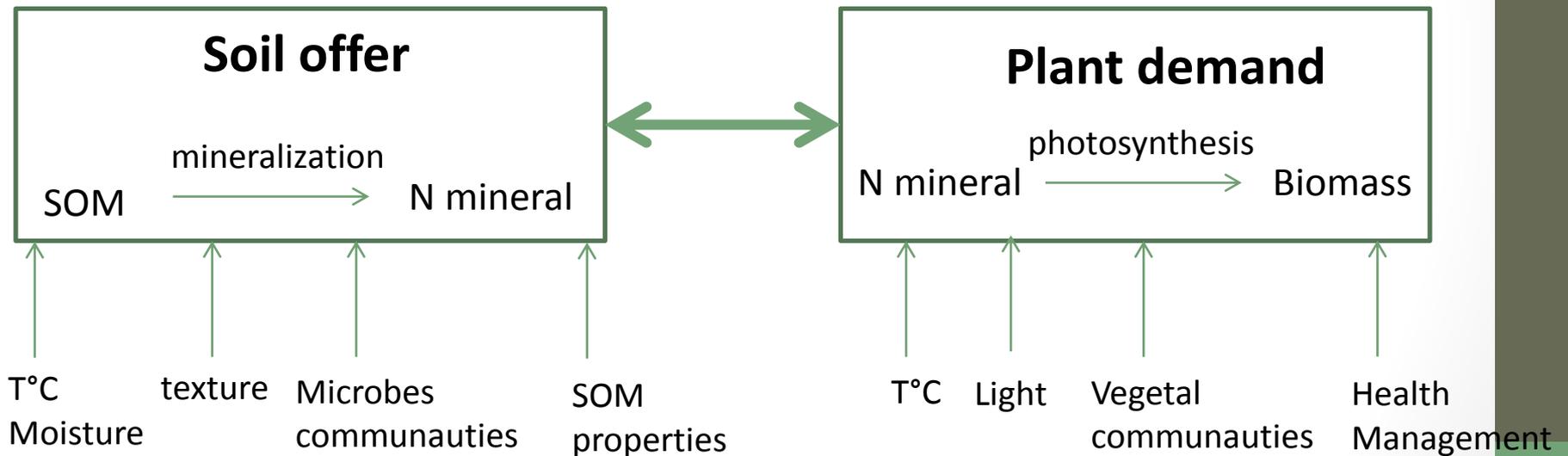
Lleida

April 2016



Introduction

- Factors controlling plants growth and microorganisms activities are different



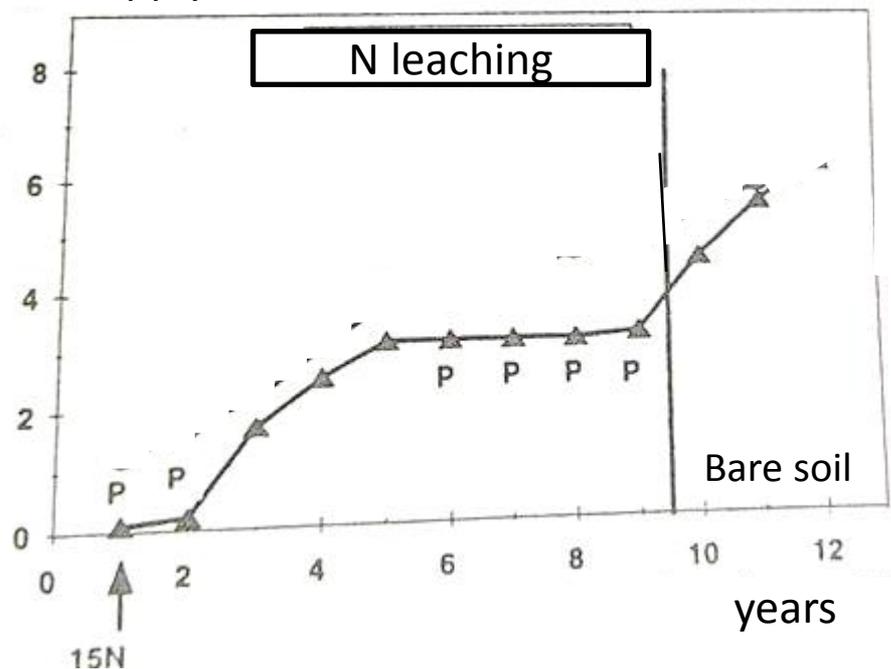
→ Few probability to observe a synchronization between them

In grassland

- Few leaching → N uptake by plant
→ Grassland is a quite autonomous agroecosystem

% N supply

Recous *et al.*, 1997



Annual crop

P

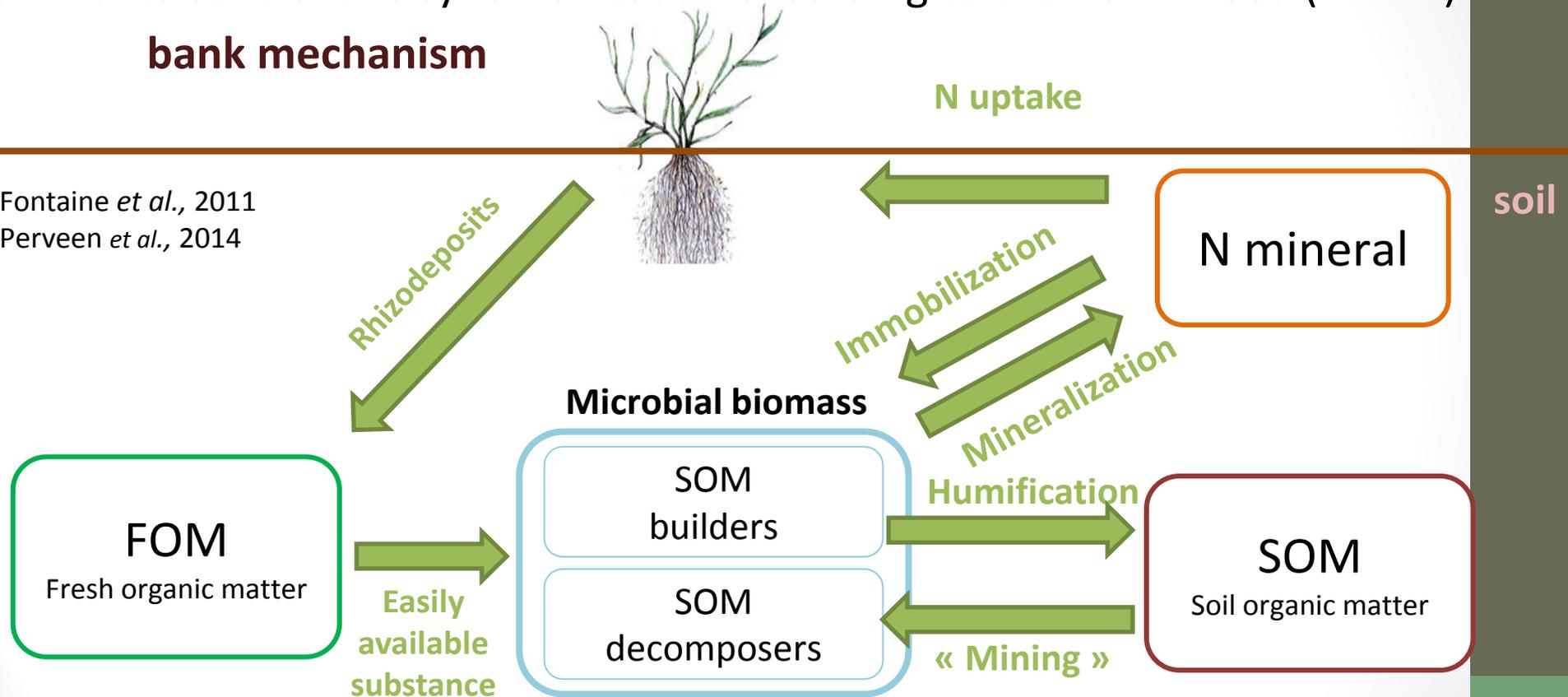
Grassland presence

Presence of synchronization between plant N-demand and soil N-offer ?

In grassland

- Plants control this synchronization according to their own need (model):

bank mechanism



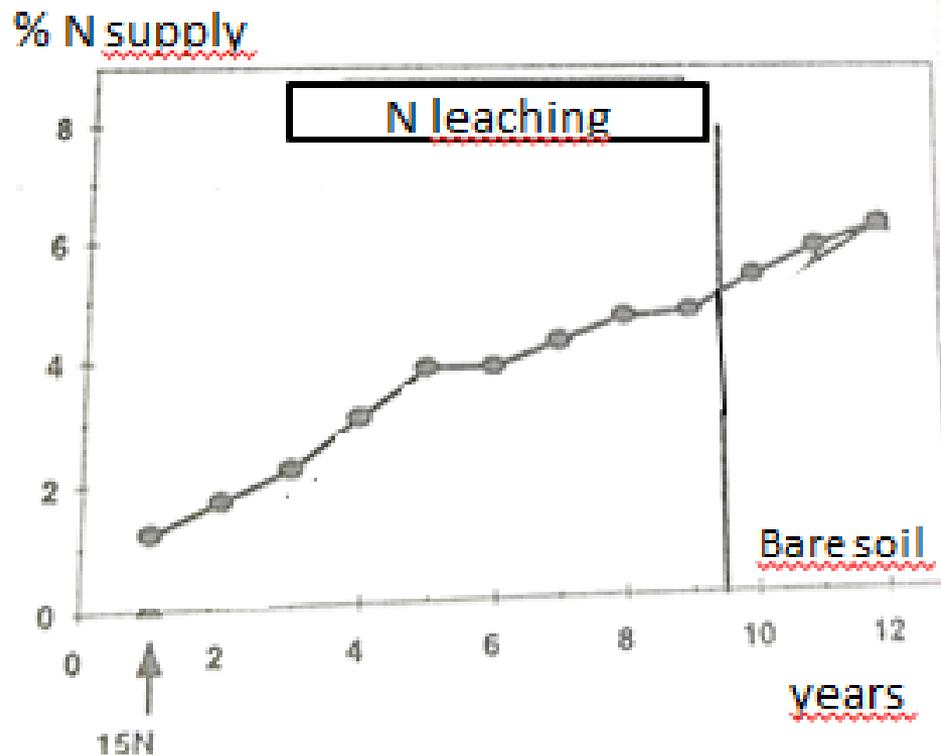
Rhizosphere regulation intensity change according to N and C availability

In grassland: Questions

- Do we observe a synchronization between plant demand and soil offer with a grass species ?
- How evolve rhizosphere process with a legume intercrop (N treatment)?
- How evolve rhizosphere process and ecosystem balance in a elevated CO₂ environment in grassland (grass alone and intercrop) ?

In conventional crop

- High leaching → N lost in environment
→ dependent to fertilizer
→ soil exhaustion



● Annual cropping

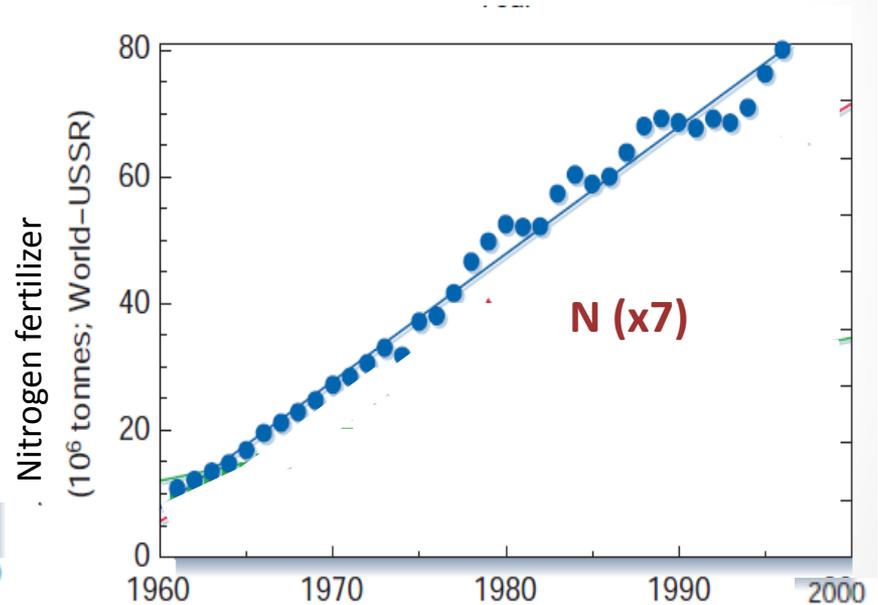
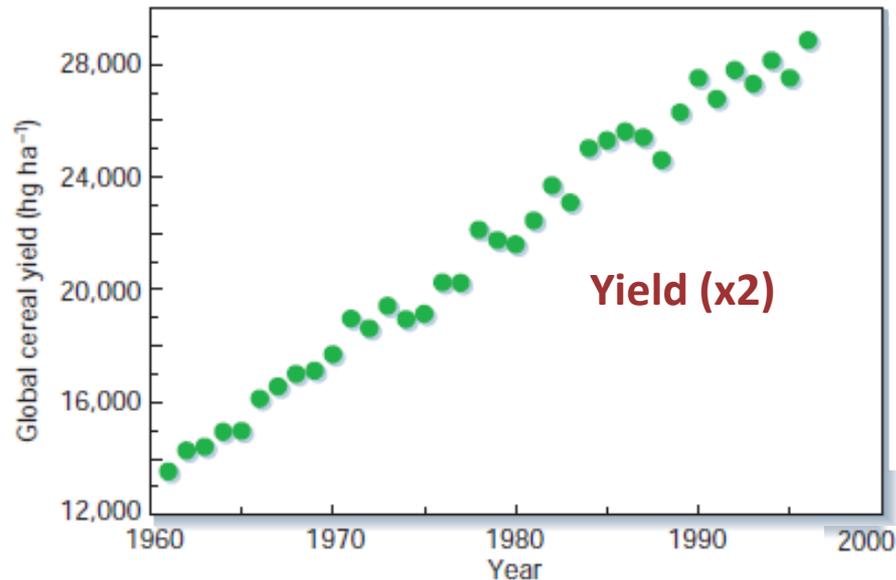
In conventional crop: Question

- Do we observe a synchronization in conventional annual crop ?

We hypothesize no due to absence of perennial species

In agro-ecological design

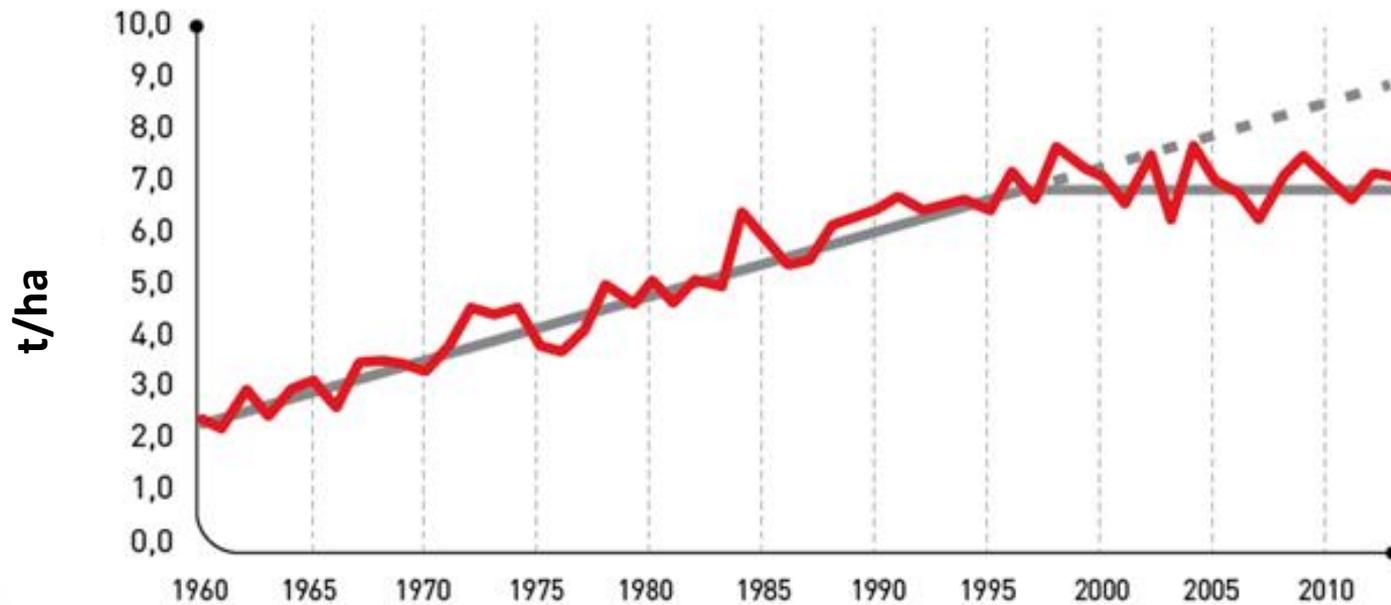
- Increasing use of fertilizer, no longer followed by a matching increase in crop-production



In agro-ecological design

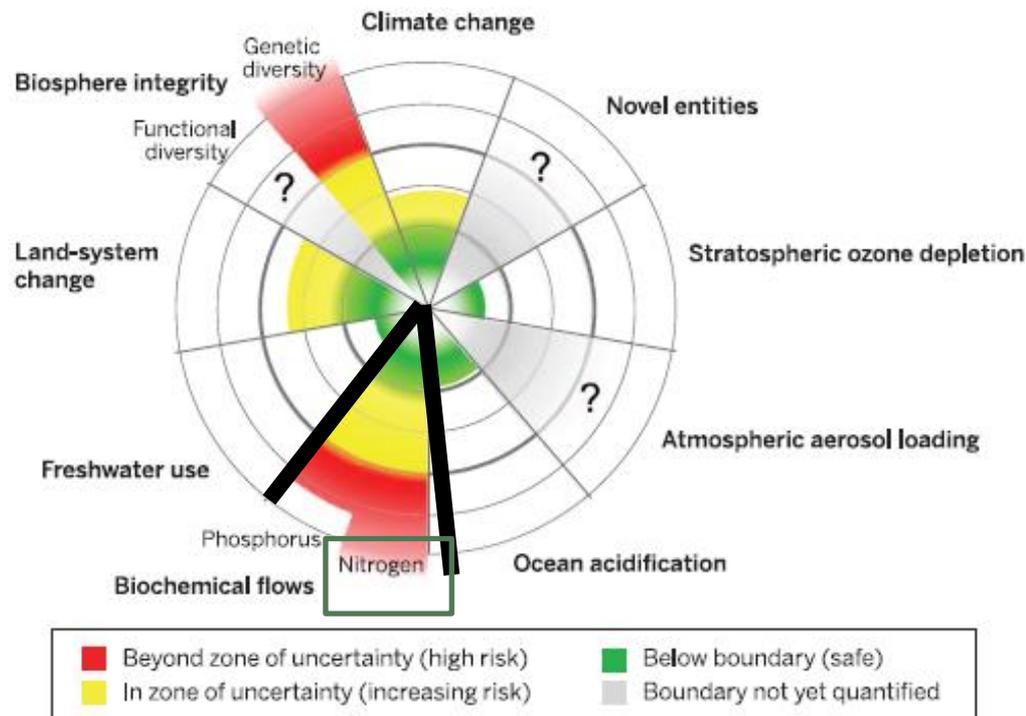
- Stagnation of production after 2000

Wheat Yield in France



In agro-ecological design

- Conventional crop: source of high environmental impact



In agro-ecological design

→ Importance to find another way of production

- We want to use the presence of synchronization in natural ecosystem (ie: grassland) to restore it in crop production
- To observe that we set up wheat / grassland intercrop

❑ Could we observe a synchronization between N demand and soil offer in innovative agroecosystem?

❑ How evolve rhizosphere process according to N fertilizer intensity ?

Transversal question

□ Understand: how occur plant/soil synchronization according to season?

→ Difference in plant and microbes activities through seasons (Bardgett et al., 2005)

We hypothesize rhizosphere process are different according to season:

→ storage during autumn/winter and release during spring/ summer

We suppose the importance of perennial species in this plant/soil synchronization

To answer those questions

....

10 plants treatments with 4 repetitions :

- 3 species + Manipulation of Nitrogen and Carbon availability



English Ryegrass



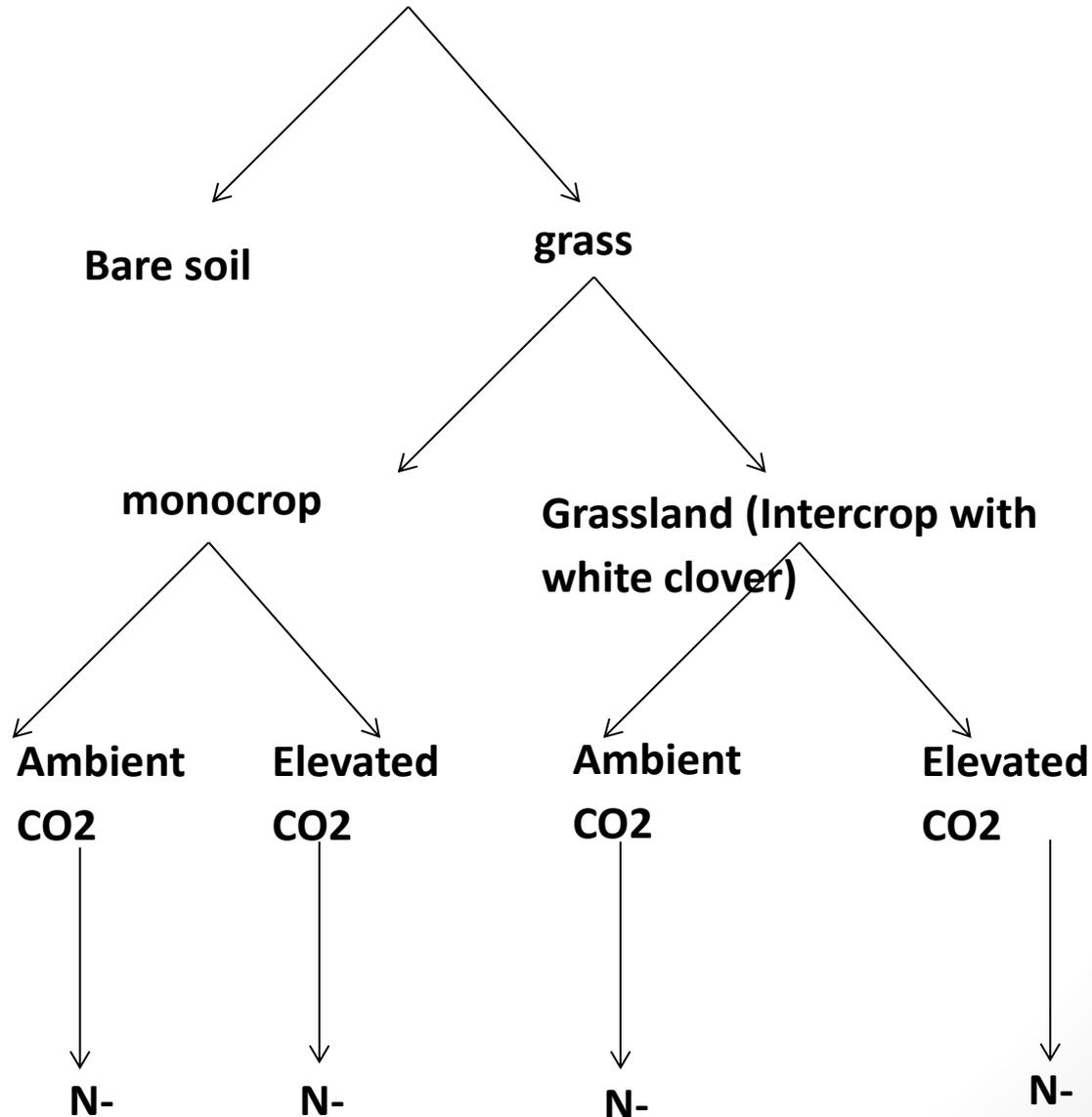
White clover



Wheat

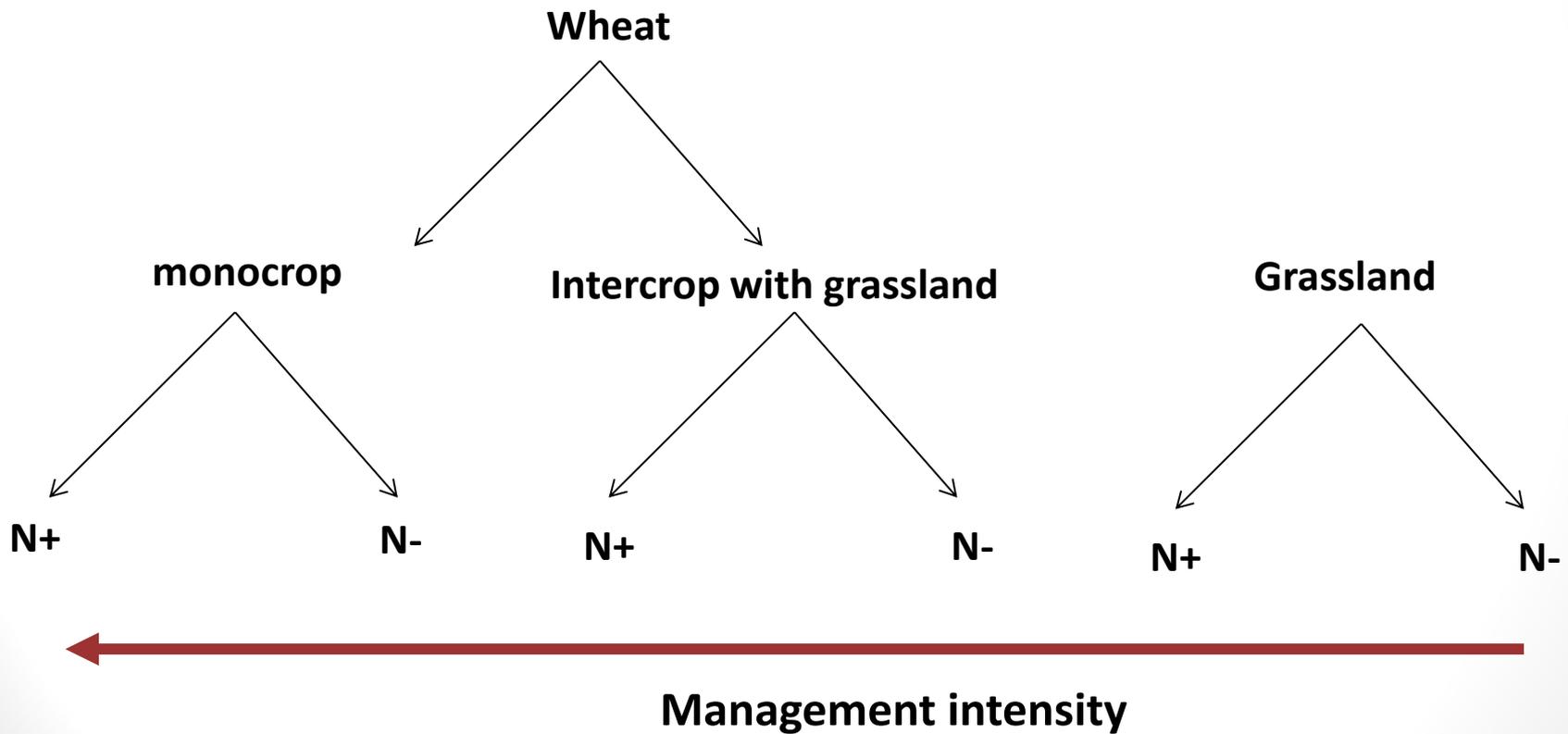
Questions related to synchronization in grassland ecosystem

5 treatments



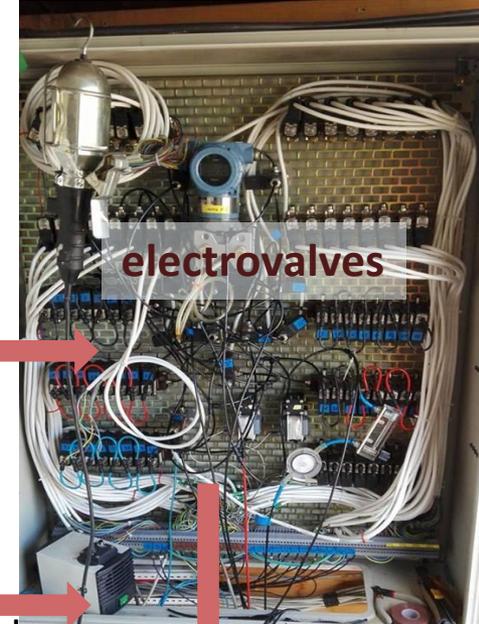
Questions related to land use: How evolve synchronization according to management intensity ?

6 treatments



Experimental devices

Labeling platform ($^{13}\text{C}\text{O}_2$) and gas exchanges measurements



Input
sample

output
sample

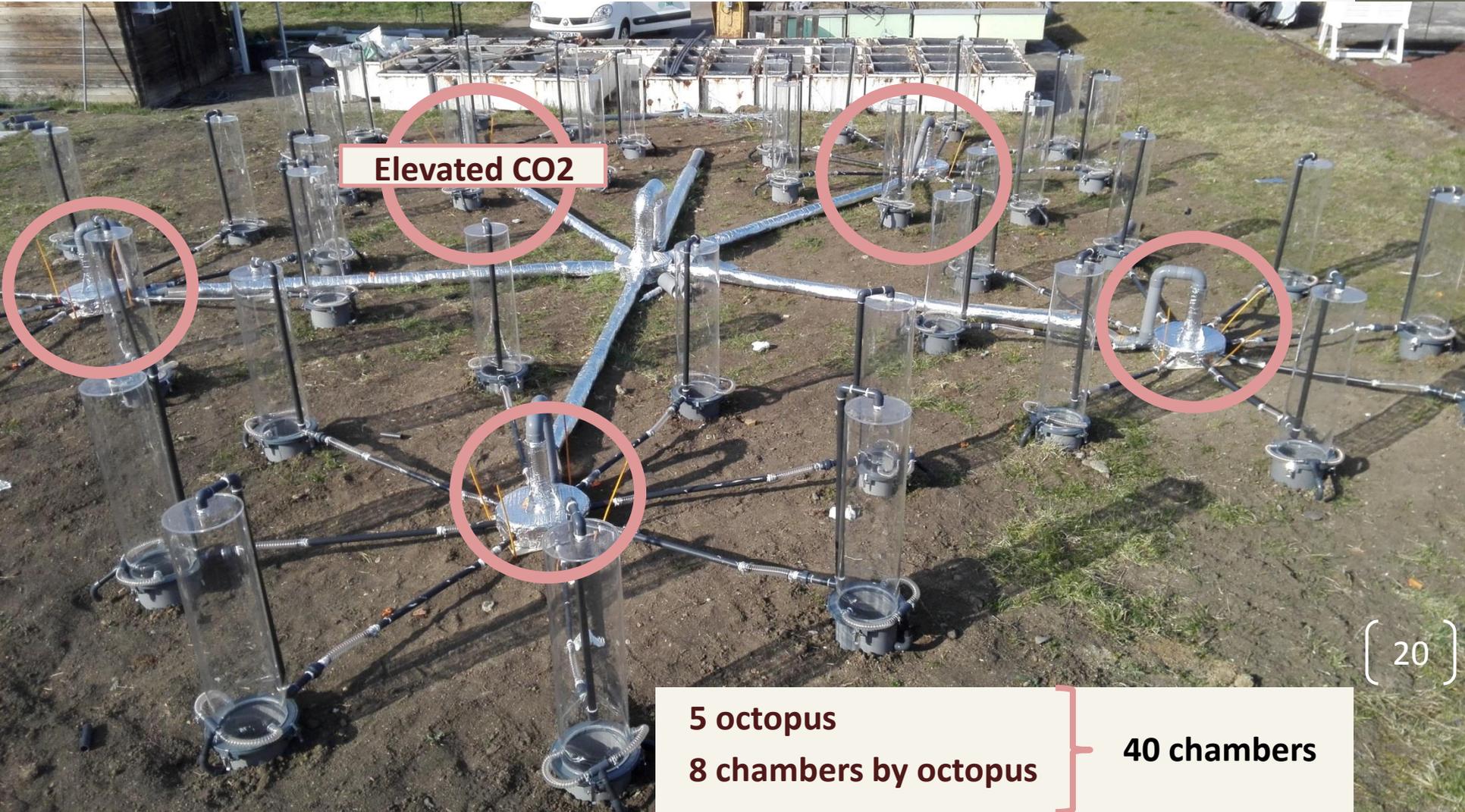


Labeling platform (13C02) and gas exchanges measurements

Innovative design with 13C continuous labeling for 2 years



Labeling platform ($^{13}\text{C}\text{O}_2$) and gas exchanges measurements

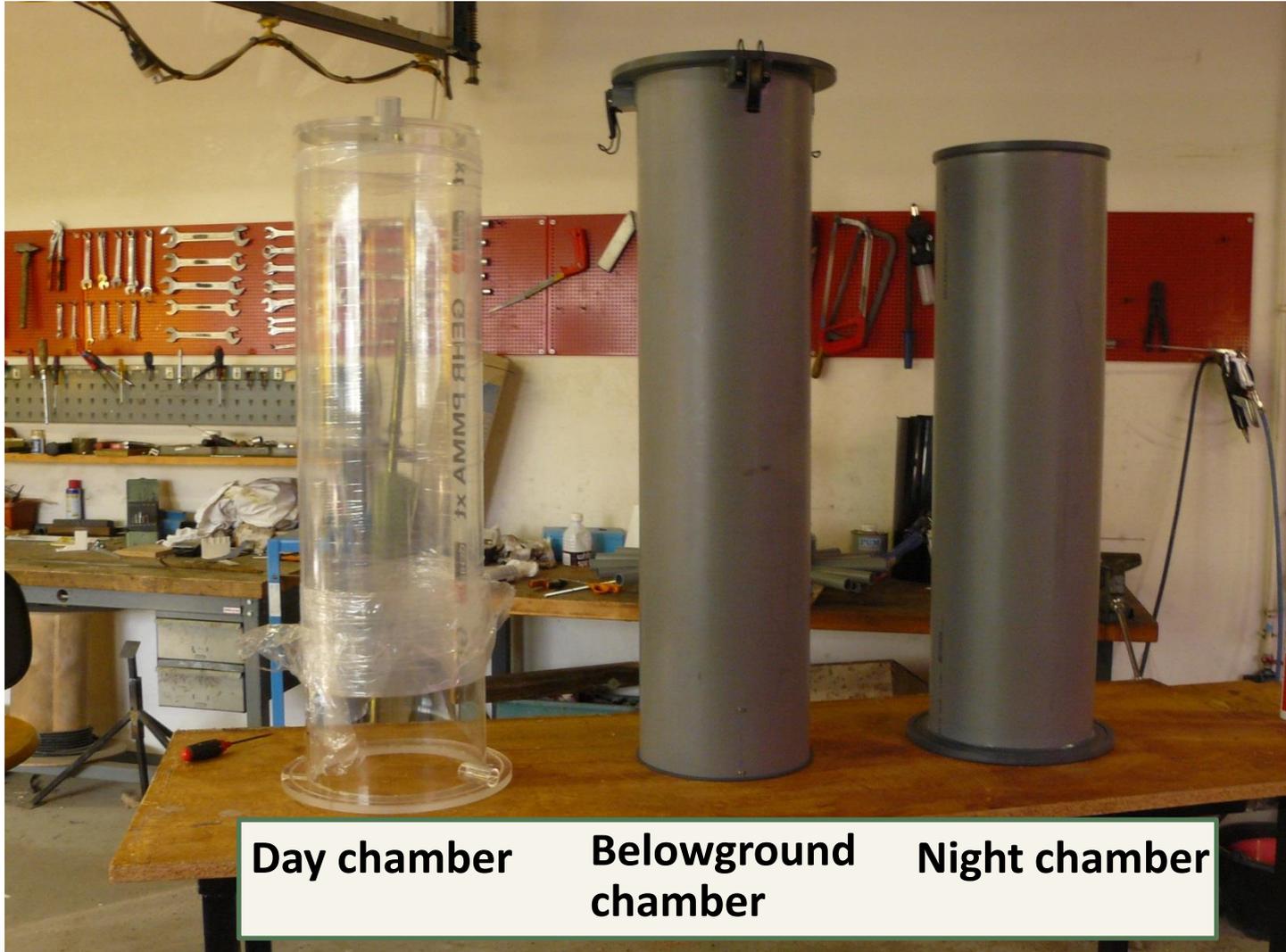


Elevated CO_2

(20)

**5 octopus
8 chambers by octopus** } **40 chambers**

The chambers



Day chamber

**Belowground
chamber**

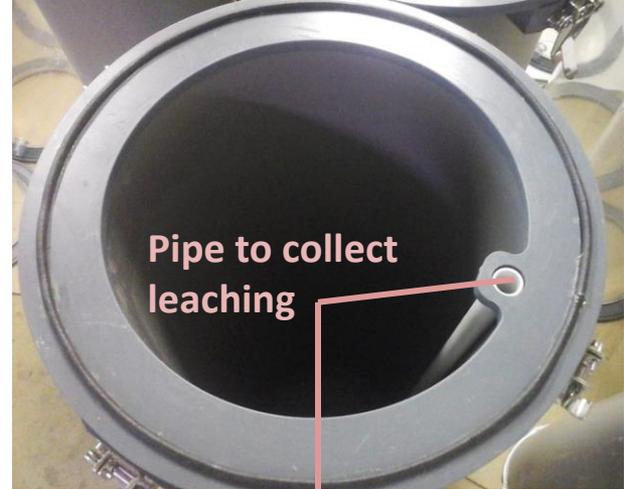
Night chamber

The chambers

Belowground chamber



- Leaching collection



The chambers

Belowground chamber

- Buried at 80 cm
- Check chambers are flat in soil



The chambers

Day chamber



1 input

- Continuous measures of C fluxes at entry and exit

2 outputs



The chambers

Day chamber



We can disconnect day chambers from air distribution system

The chambers

Night chamber



- Measure respiration of microbes/plant system

→ Permit to determine RPE



Measured ecosystem functions

- Continuously:
 - Net ecosystem exchange
 - Ecosystem respiration
 - Plant photosynthesis (GPP)

- Bi-monthly:
 - Plant (labeled) C respiration
 - Soil (unlabeled) C respiration
 - Rhizosphere priming effect
 - Emissions of N₂O
 - Emission or fixation of methane

- Seasonally
 - Leaching
 - Forage production and grain yield

Destructive measurements



2 greenhouses without continuous labeling

Elevated CO₂

Destructive measurements

Estimate microbial activity and soil N process according to seasons

→ Measurement at each sampling (one per season):

- Sampling soil to evaluate:
 - Microbial biomass
 - gross N mineralization and immobilization
 - Microbial communities: DNA, PLFA ?
- ^{15}N input to follow N distribution into plant/soil system

Destructive measurements



Greenhouse 1 at ambient CO₂

- 8 treatments
- 4 repetitions
- 3 harvest corresponding to 3 seasons

96 pots

Destructive measurements



Greenhouse 2 at elevated CO₂

- 2 treatments
- 4 repetitions
- 3 harvest corresponding to 3 seasons

24 pots

Destructive measurements

The pots

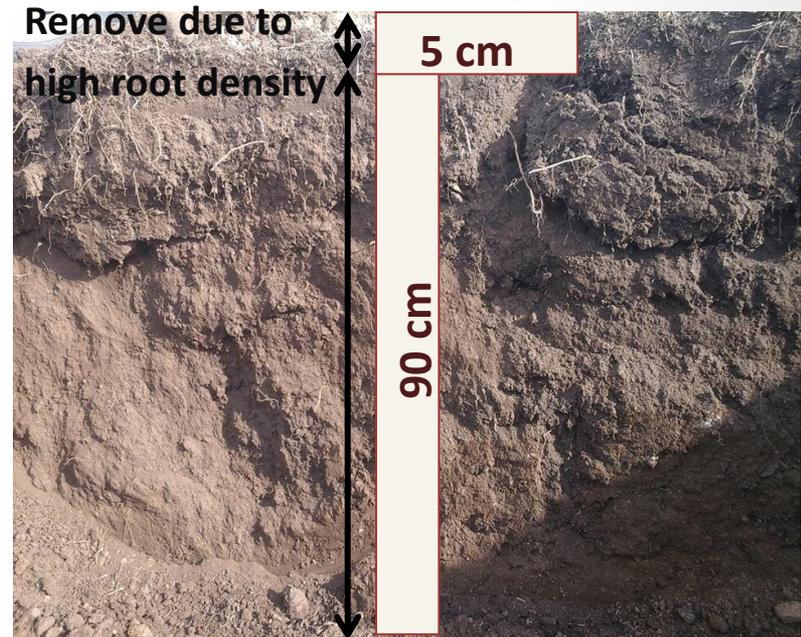


Unscrew bottom to
sample leaching

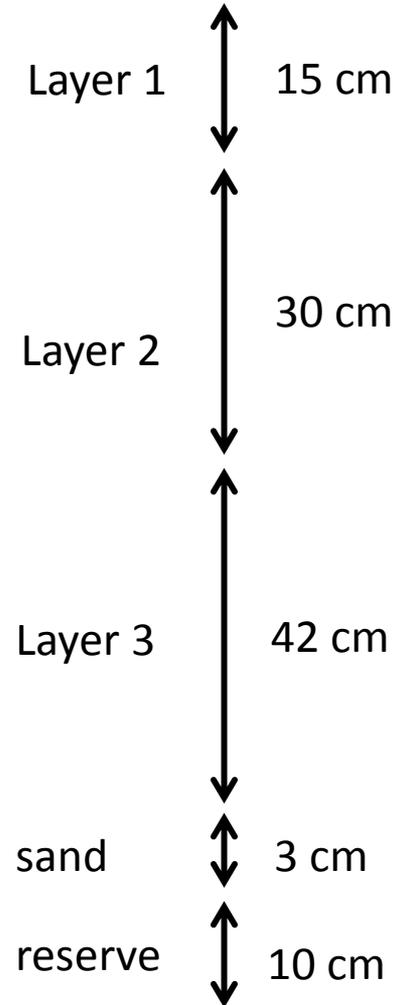


Soil

- From grassland on 0-90 cm
- 3 layers separated :
5-20, 20-50, 50-90 cm
- Each layer sieved at 1 cm



Soil in pots



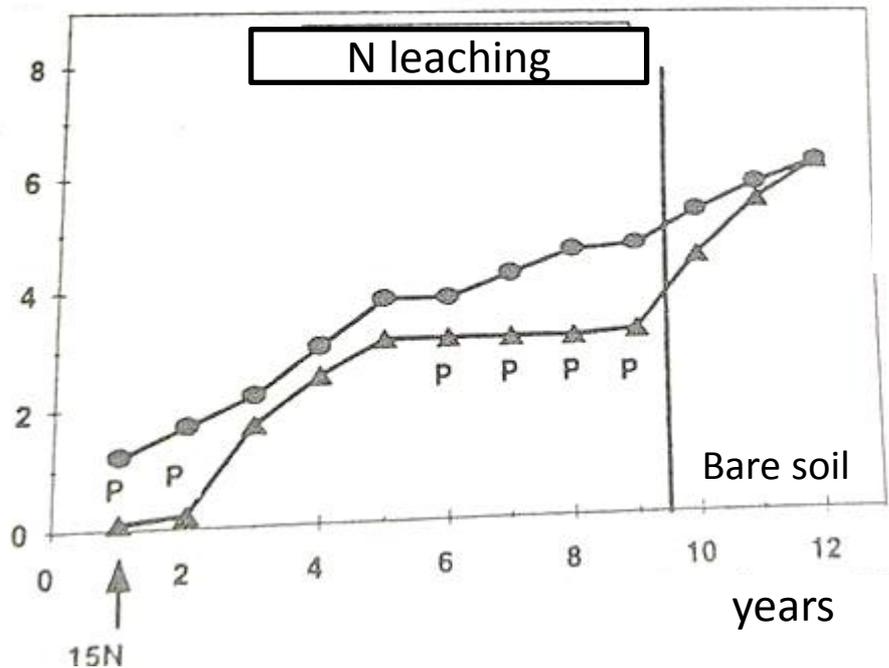
**THANKS FOR
YOUR ATTENTION**



Introduction

- In grassland, no or few leaching
- In conventional crop, high leaching

% N supply



- Annual cropping
- ▲ Rotation annual cropping and grassland
- P Grassland presence

Common questions

❑ Understand how occur this synchronization according to C and N availability ?

→ According to Perveen et al (2014) and Fontaine and Barot (2006), presence of differences according to nutrients availability

❑ Understand how occur plant/soil synchronization according to season?

→ Difference in plant and microbes activities through seasons (Bardgett et al., 2005)

Set up: space station

Day chamber



measuring point



Set up to characterize ecosystem C and N cycling

2 types of set up

