Biodiversity and rhizosphere process in plant/soil synchronization

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News from Clermont Ferrand

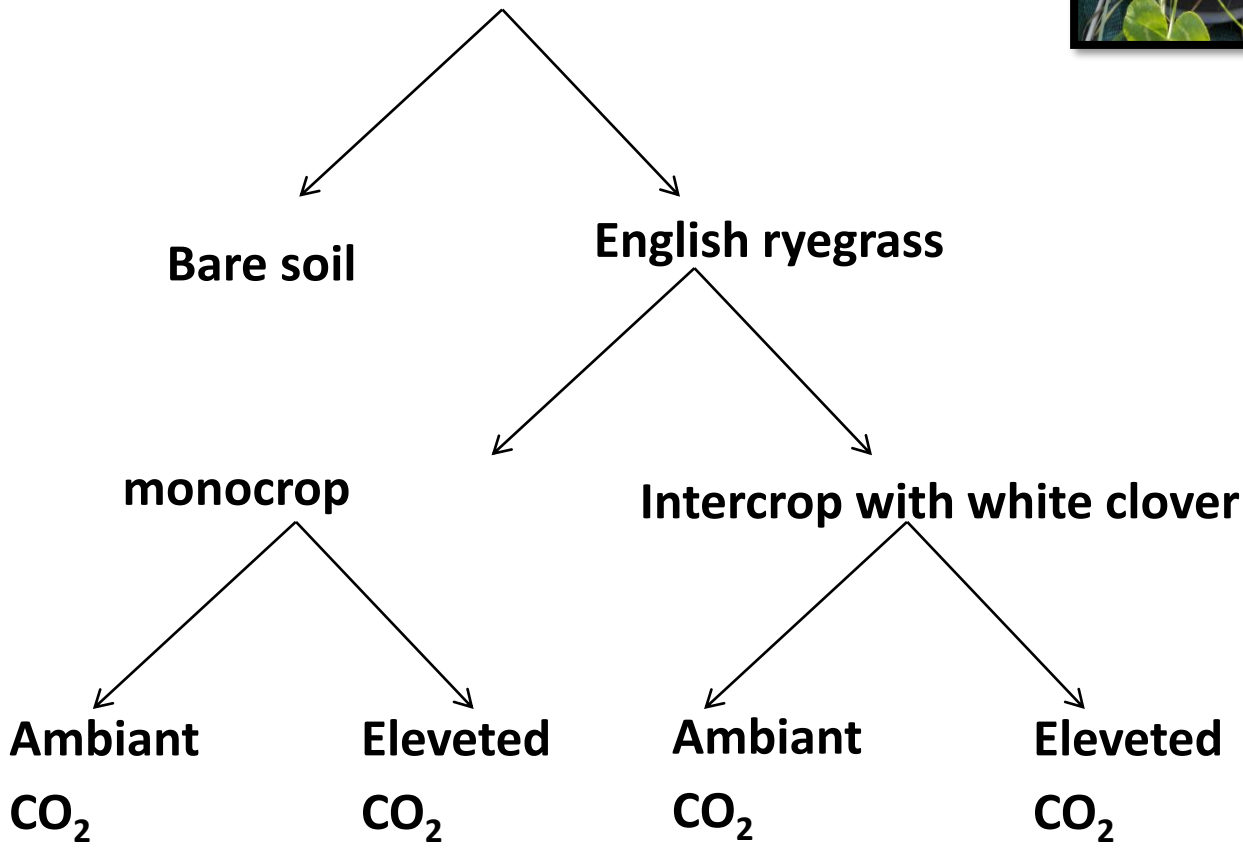
CROS Camille, ALVAREZ Gaël, KEUPER Frida, REVAILLOT Sandrine, FALCIMAGNE Robert, **FONTAINE Sébastien**

Evolution of the results presented last year

What is the consequences of plant functioning modification due to CO_2 increase on soil processes ?

Design

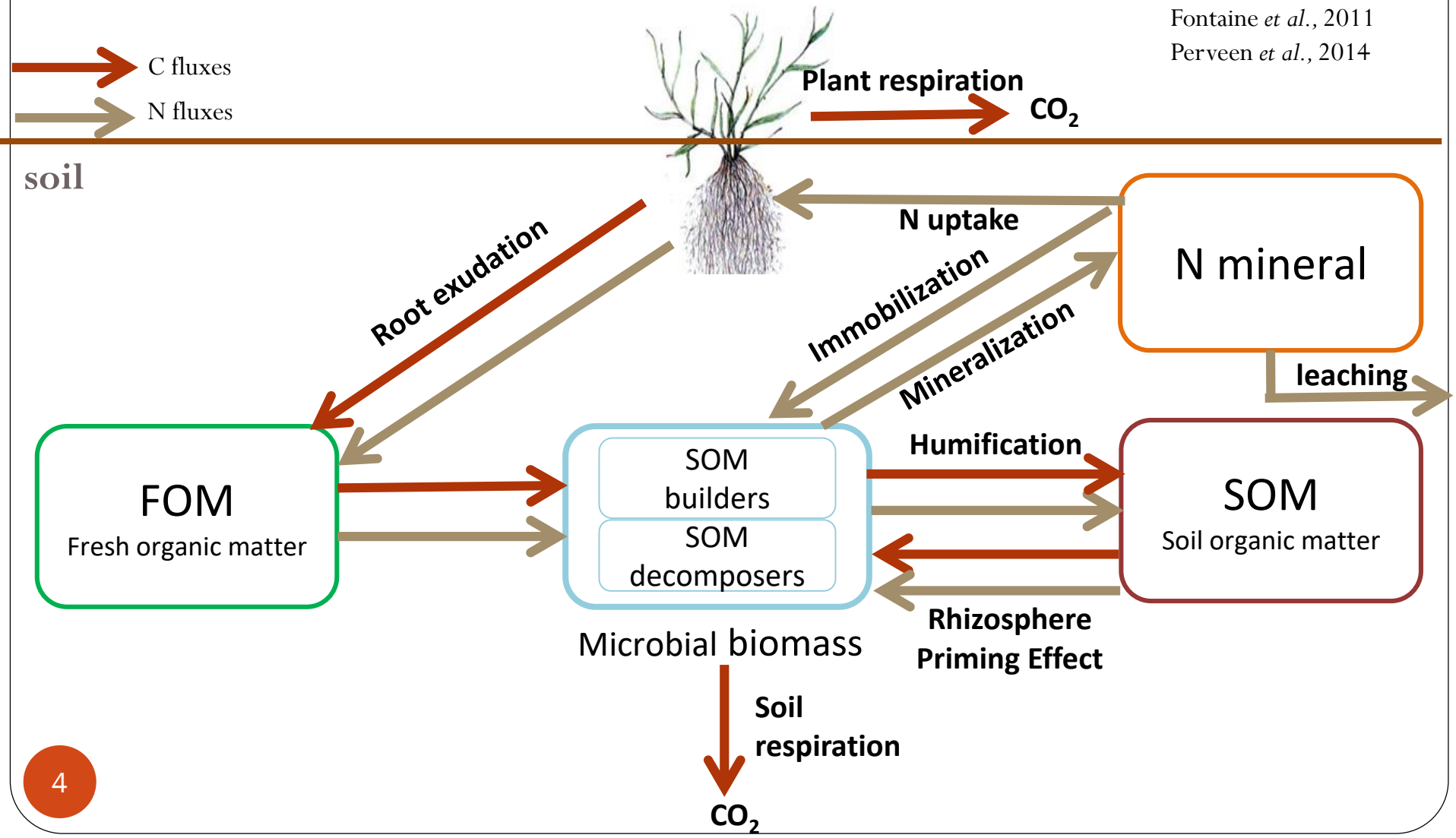
- 2 species
- Sown in September 2016
- CO_2 levels (C ambiant: 400 ppm; C eleveted: 700 ppm)
- 4 replicates
- 3 plants destructives harvests in 2017



Bank mechanism

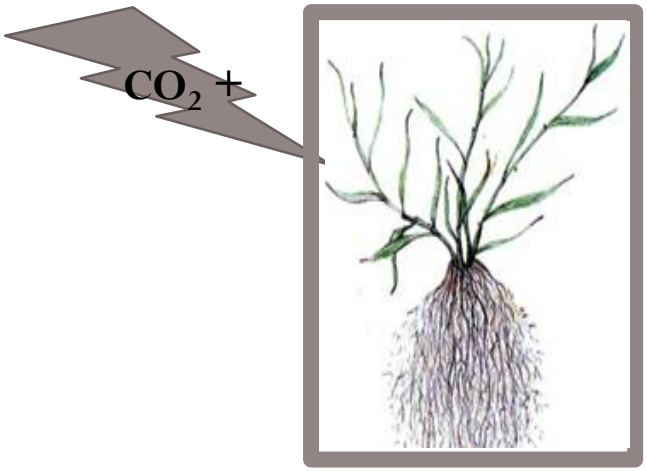
Synchronisation between plant N-demand and soil N-offer

Fontaine *et al.*, 2011
Perveen *et al.*, 2014



Hypothesis

arising from bank mechanism



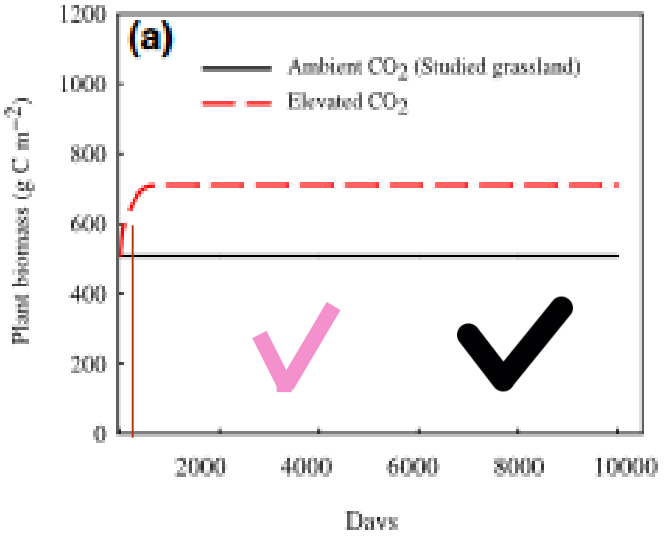
Photosynthesis stimulation

1. Biomass increasing (+ root exsudation)
2. Decrease of mineral N
3. RPE increasing
4. Destocking SOM

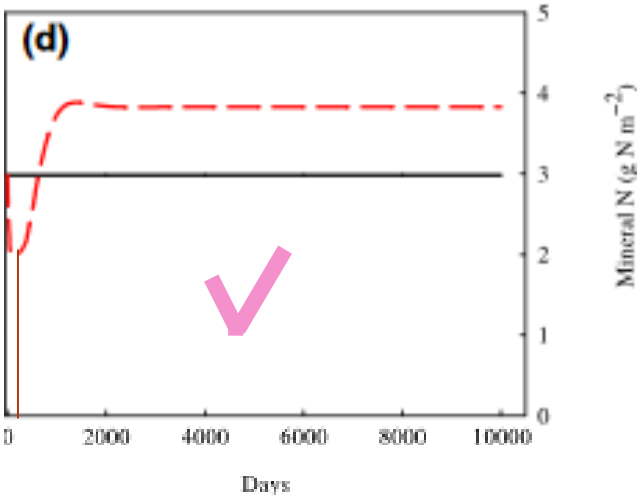
Perveen et al., 2014

Reminder of principal results from last year

Plant biomass



Mineral N



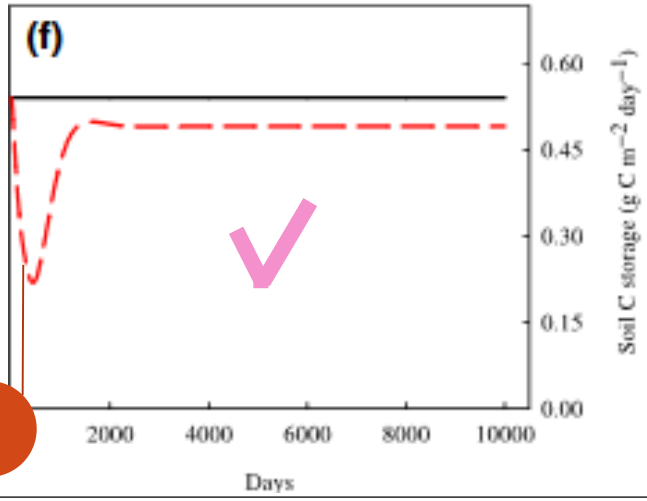
Effect of elevated CO2 in adequation

In monocrop

In intercop

Adapted from Perveen *et al.*, 2014

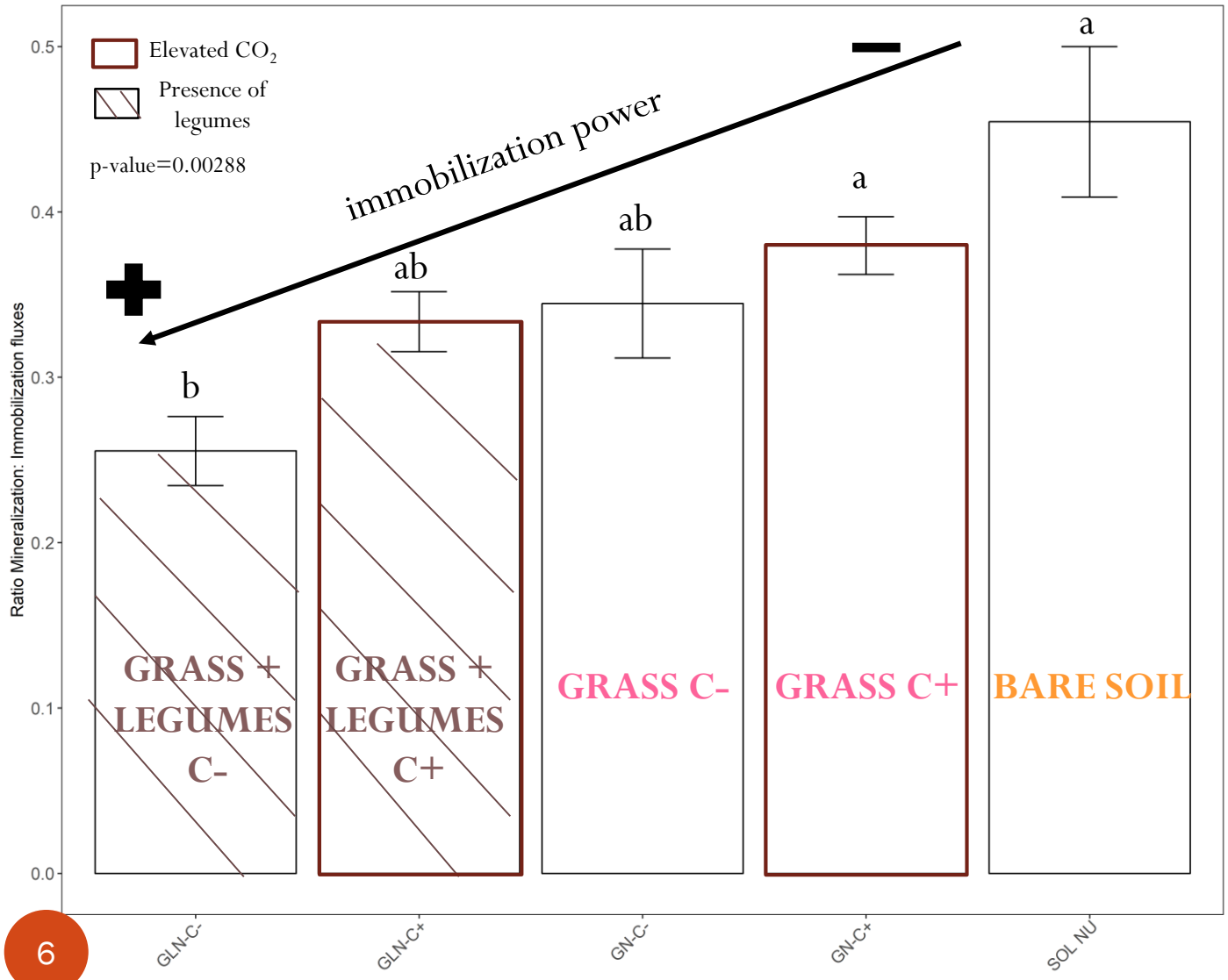
Soil C storage



- In long term, increase of SOM decomposition → decrease of soil stock
- Attenuation with legumes

Hu *et al.*, 2001; Dijsktra *et al.*, 2013; Perveen *et al.*, 2014; Nie *et al.*, 2016; Vestergard *et al.*, 2016;

News results seems to confirm

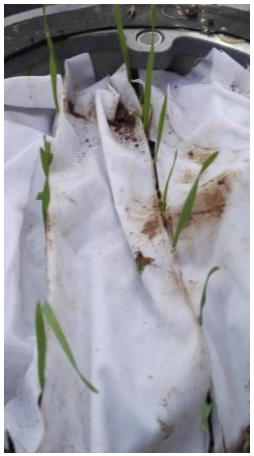


- Less power of imobilization in elevated CO_2
- Gradient of immobilization capacity

→ **Higher in presence of legumes**

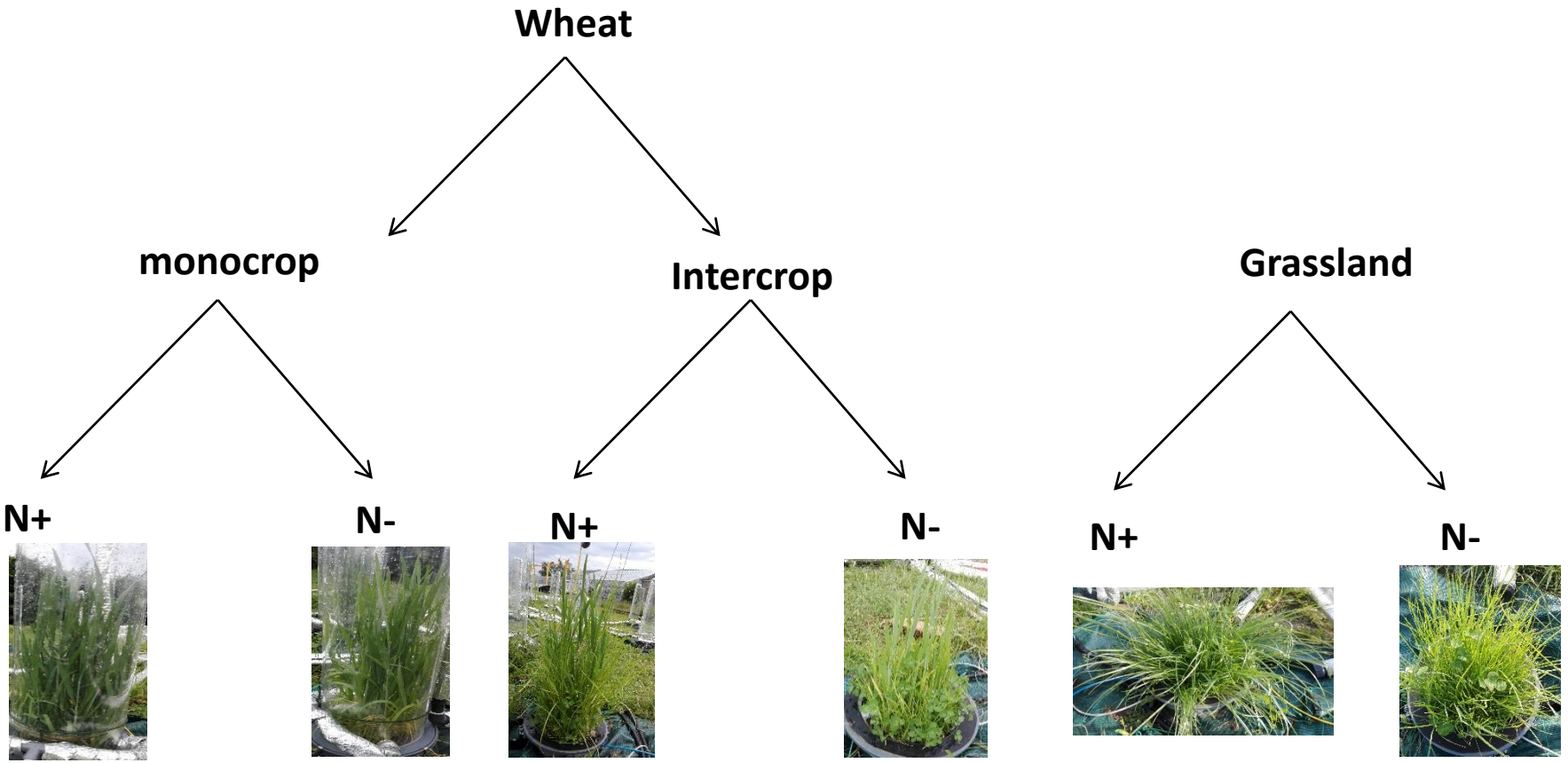
→ **Probably higher storage capacity**

Some results on Land-use effect



Land-uses

Treatments



Management intensity

Hypothesis

Can we find adapted land uses to solve the synchronization problem between plant-N demand and soil-N offer in conventional crop?

Recous *et al.*, 1997
Chabbi & Lemaire, 2007

Grassland ecosystem

- Presence of perennial species
→ continuous C input
- High microbial biomass, diversity of microbial activity
→ regulation power
- High potential of N immobilization

↗ power of synchronization between plant demand and soil offer

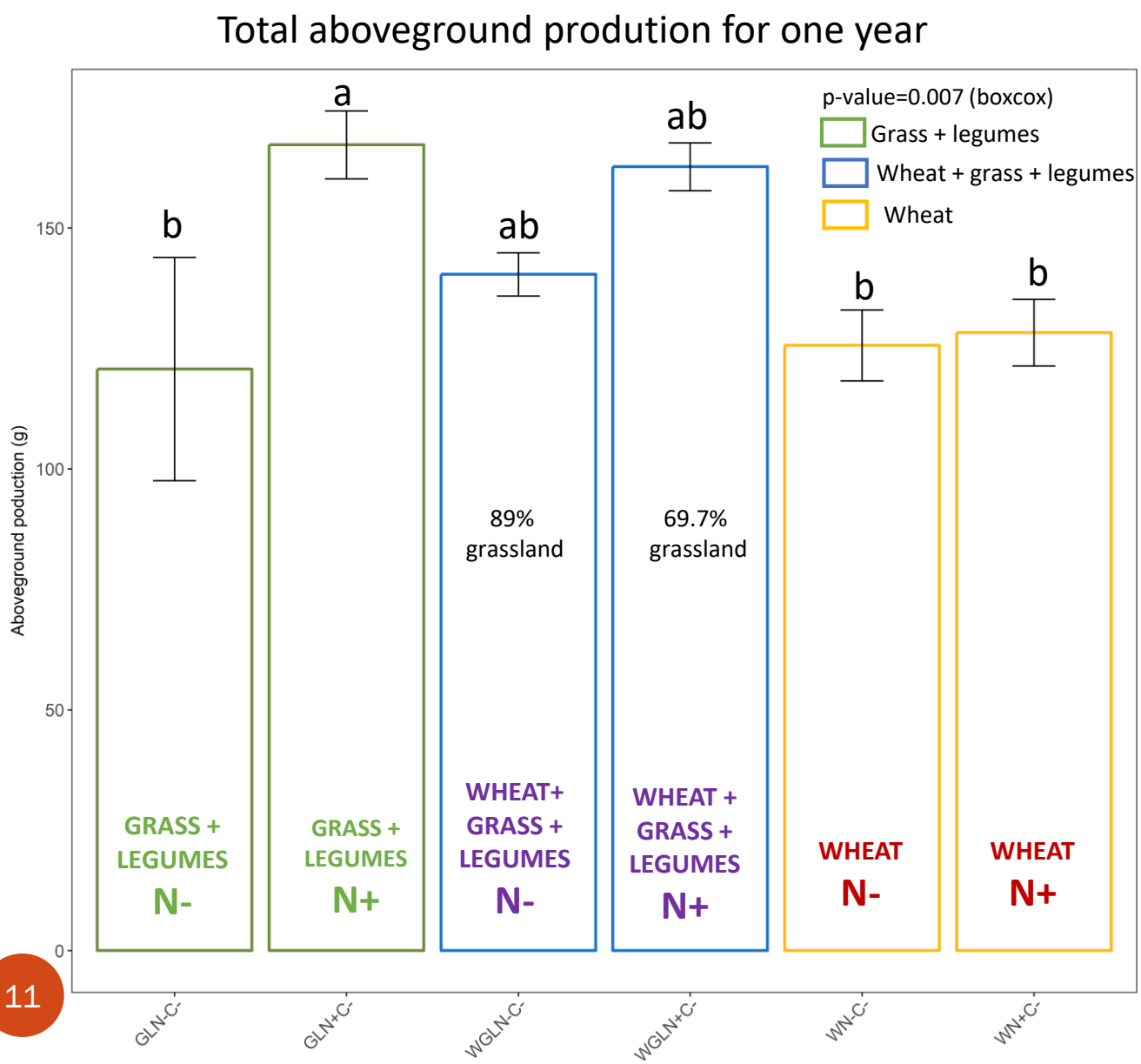
Conventional crop

- Bare soil period→ leaching
- Low biomass and microbial activity
- Low potential of N immobilization

↘ power of synchronization between plant demand and soil offer

What about innovative cropping?

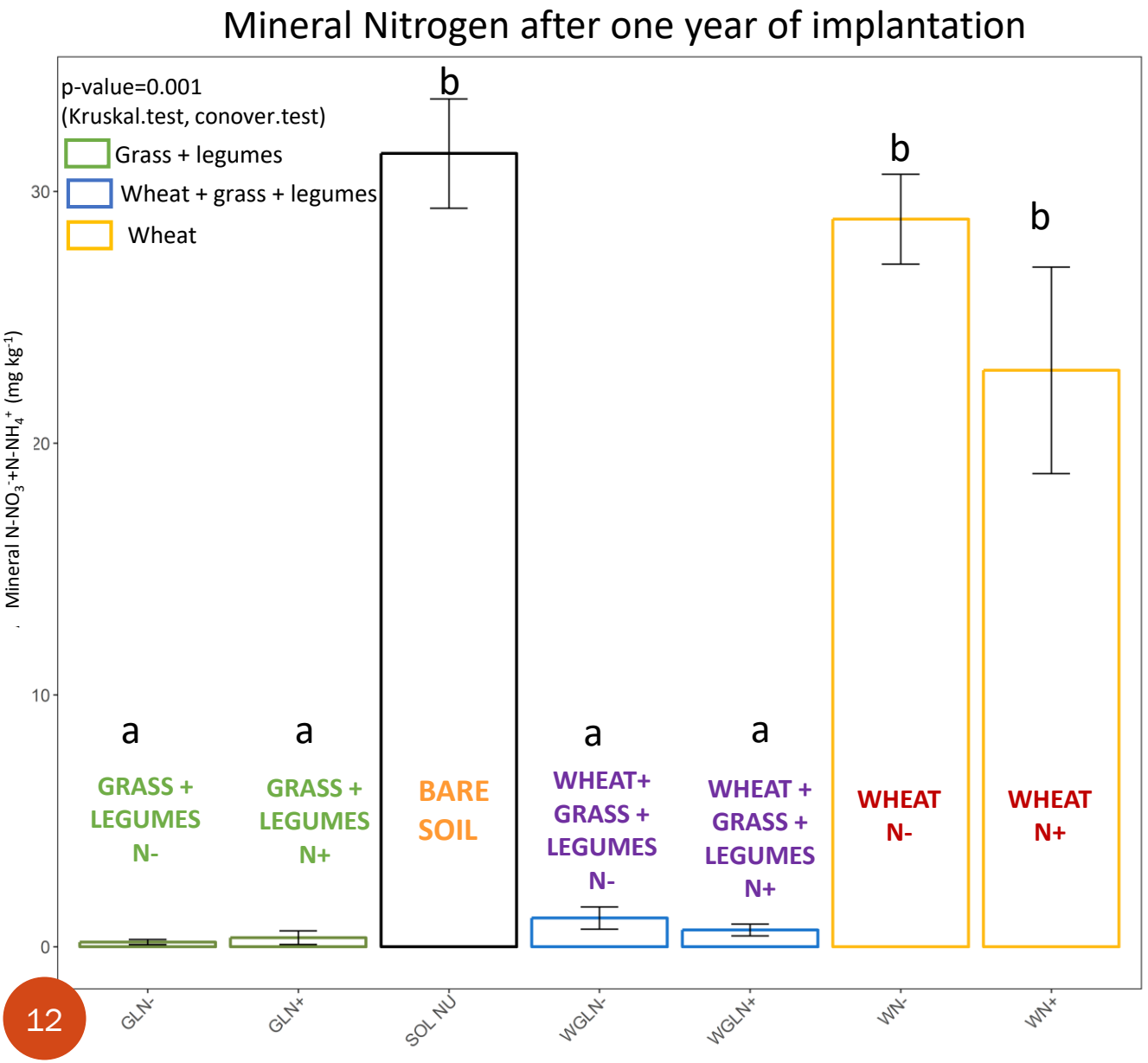
Biomass Production



- No effect of N fertilization except in grassland
- Trend: higher production in wheat intercrop compared to monocrop

Available nitrogen content in soil :

Proxy of potential leaching and N demand



- High N concentration in monocrop wheat on the three soil layers

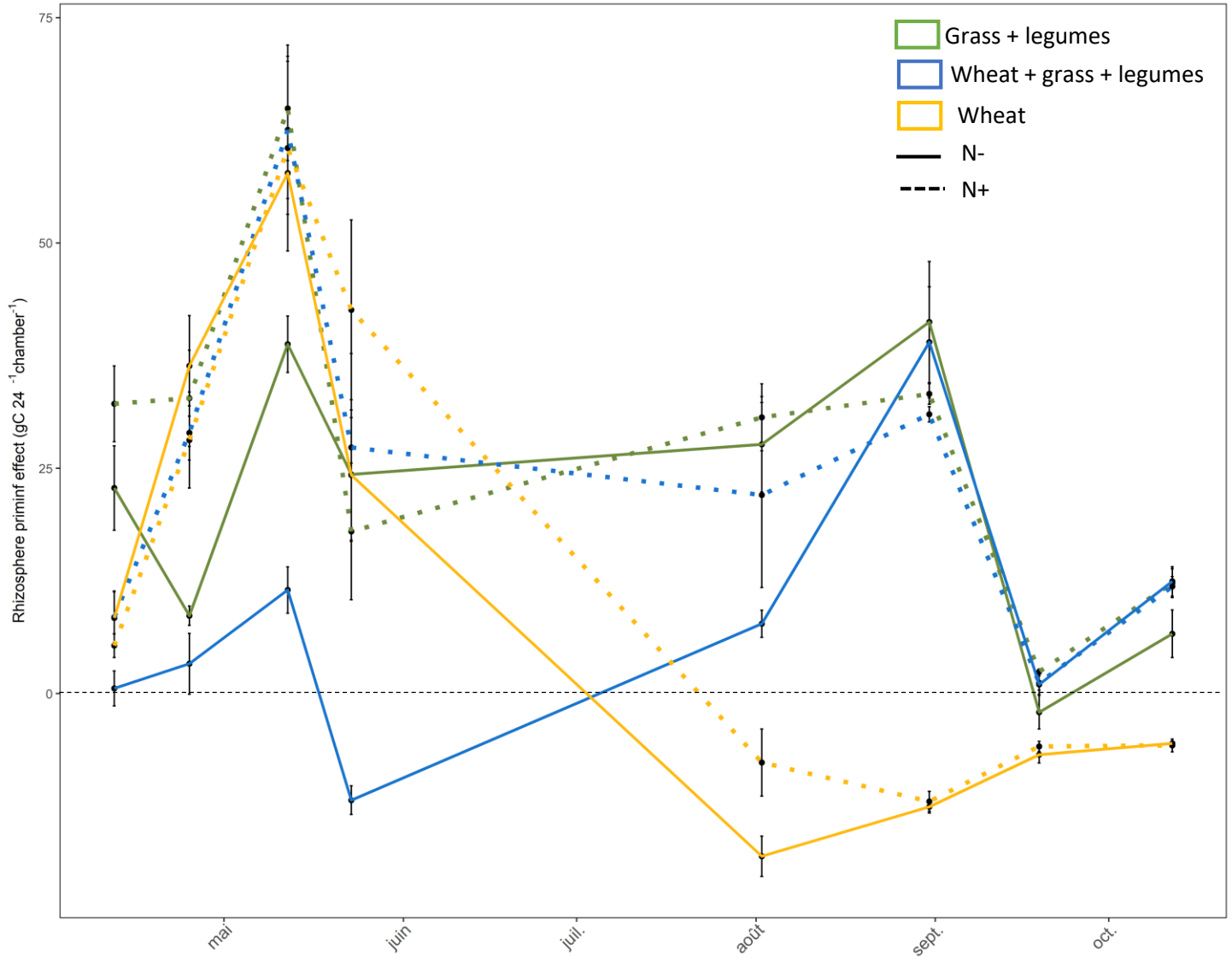
→ **High leaching capacity**

- Presence of grassland decrease N mineral

→ **High attenuation by presence of grassland**

RPE dynamics depending on N demand

Rhizosphere priming effect across time



During fertilization period : higher RPE in N+ in presence of grassland

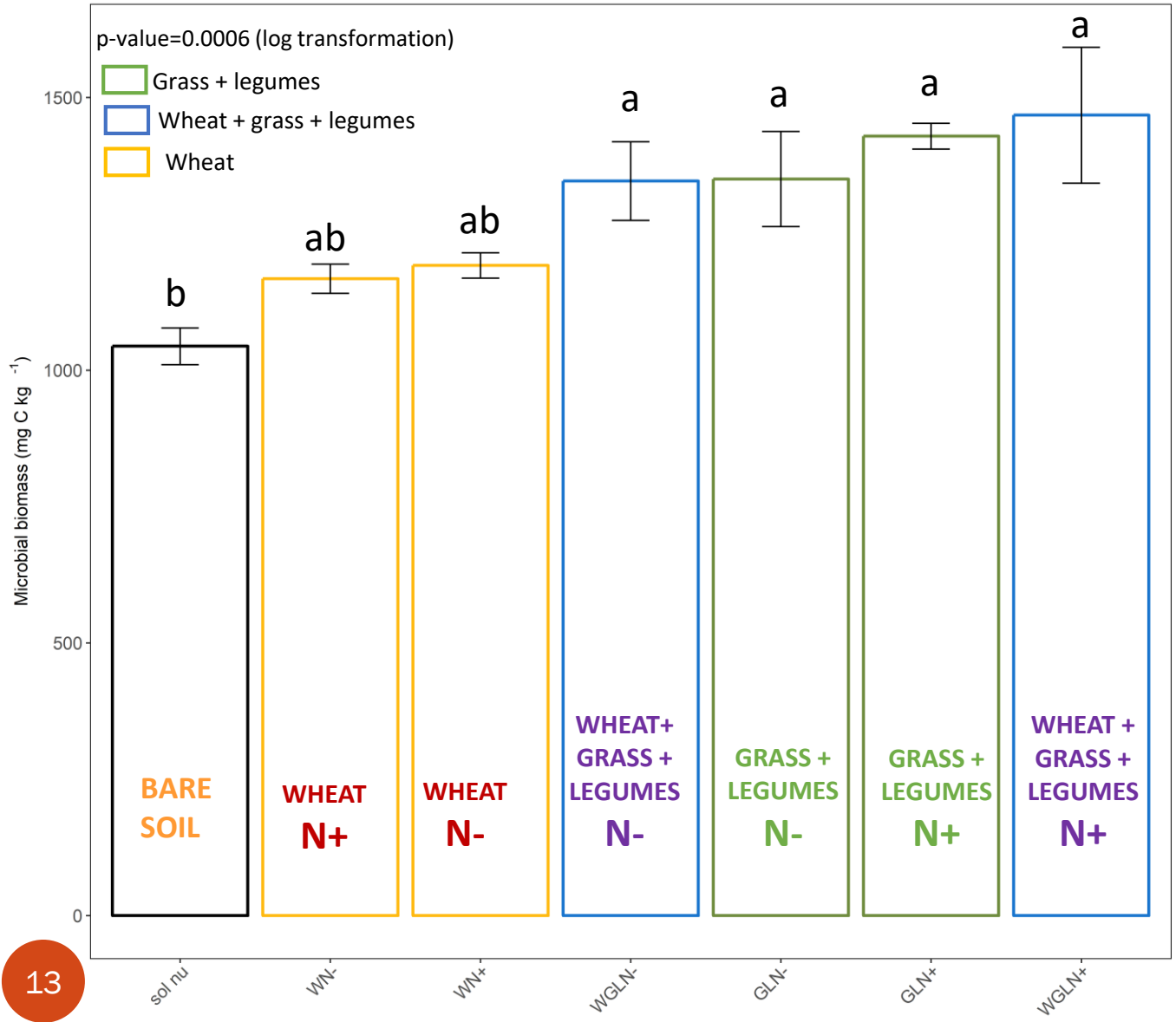
→ **Higher biomass production**
→ **Higher N demand**

During the wheat growth period: high RPE while N min was high in monocrop

→ **No efficiency in N utilisation**

Proxy of regulating power

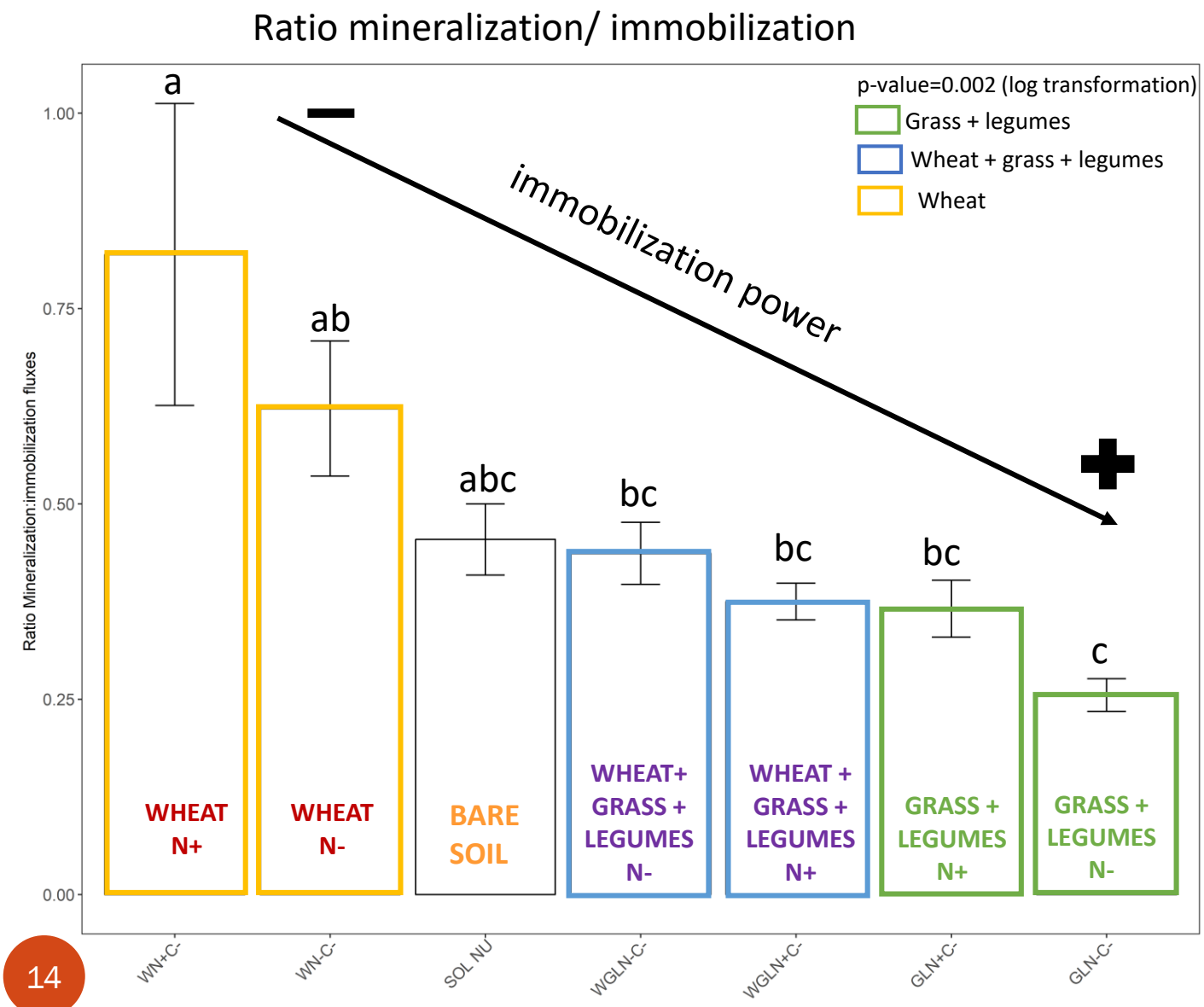
Microbial biomass after one year of implentation



- Microbial biomass higher in presence of plant
- But not significant in wheat treatments

→ **Higher potential of regulation in presence of grassland**

Potential of immobilization



- Low immobilization power in wheat monocrop

→ **Low storage capacity**

- Attenuation in intercropping system

→ **Higher storage capacity**

Conclusion

Recous *et al.*, 1997

Grassland ecosystem

- Low leaching capacity
- High microbial biomass
- High potential of N immobilization

→ **Potential storage through immobilization**
→ **Ecosystem quite dependent and perennial**

↗ power of synchronization between plant demand and soil offer

Conventional crop

- High leaching capacity
- Lower microbial biomass
- Low potential of N immobilization

→ **Exhaustion of resources due to low immobilization leading to leaching**
→ **Ecosystem dependent to fertilization**

↘ power of synchronization between plant demand and soil offer

In the second year of production, we expect:
➢ observe differences in N treatments → yield decrease

What about innovative cropping?

- Low leaching capacity
- High microbial biomass
- Medium potential of N immobilization

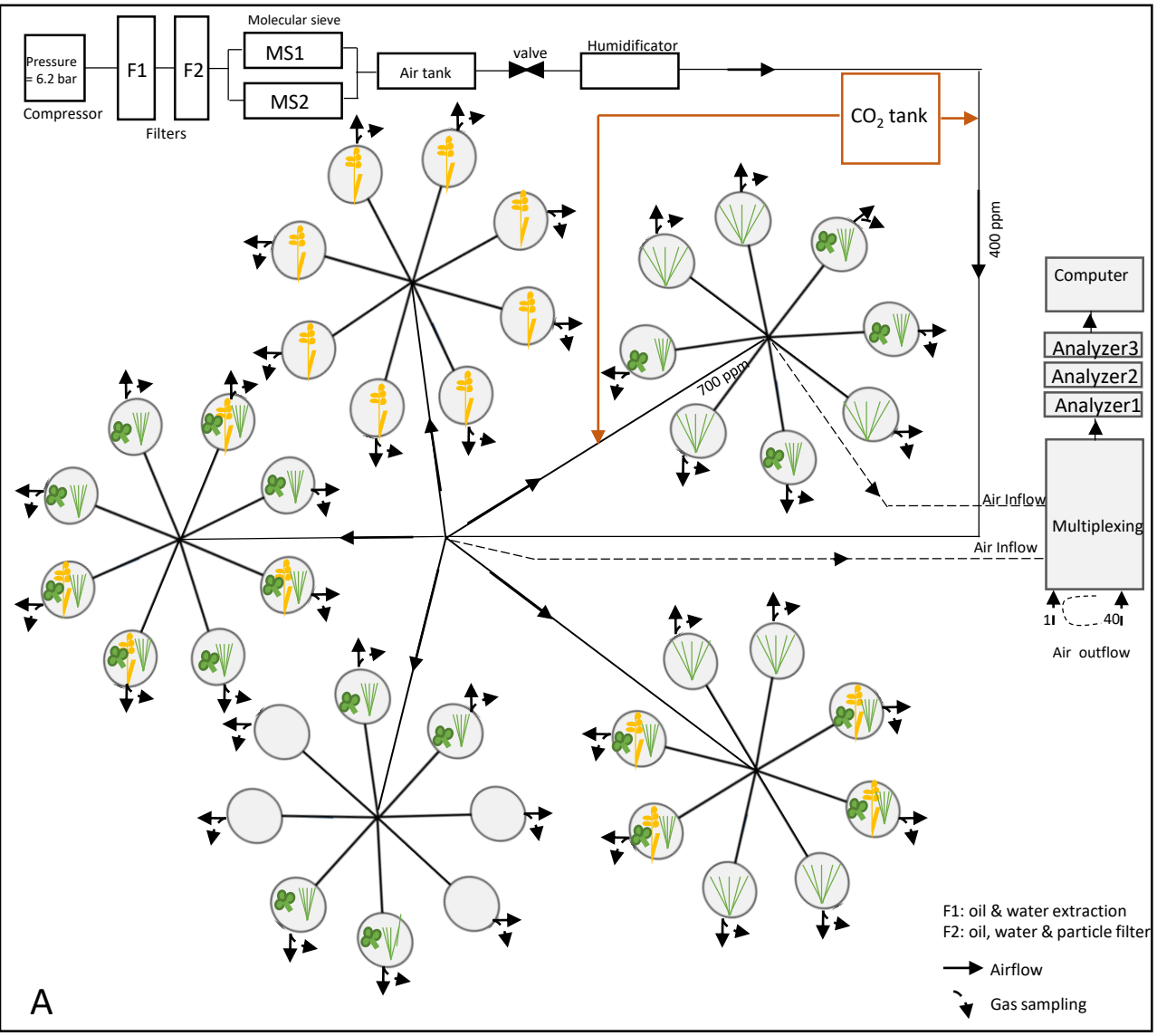
} More synchronized system
Expected to maintain yield due to N storage and presence of legumes

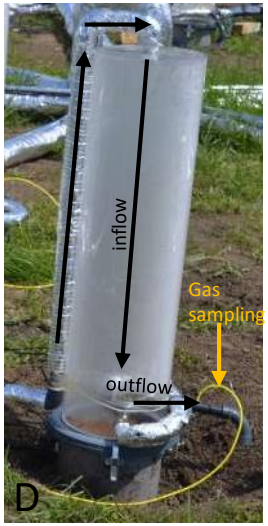
What do we do now ?

Writing a paper on the mesocosms experimental platform

Main message

An innovative mesocosm platform based on continuous CO_2 exchanges measurements and ^{13}C labeling for assessing rhizosphere priming effect and its contribution to ecosystem carbon dynamics.

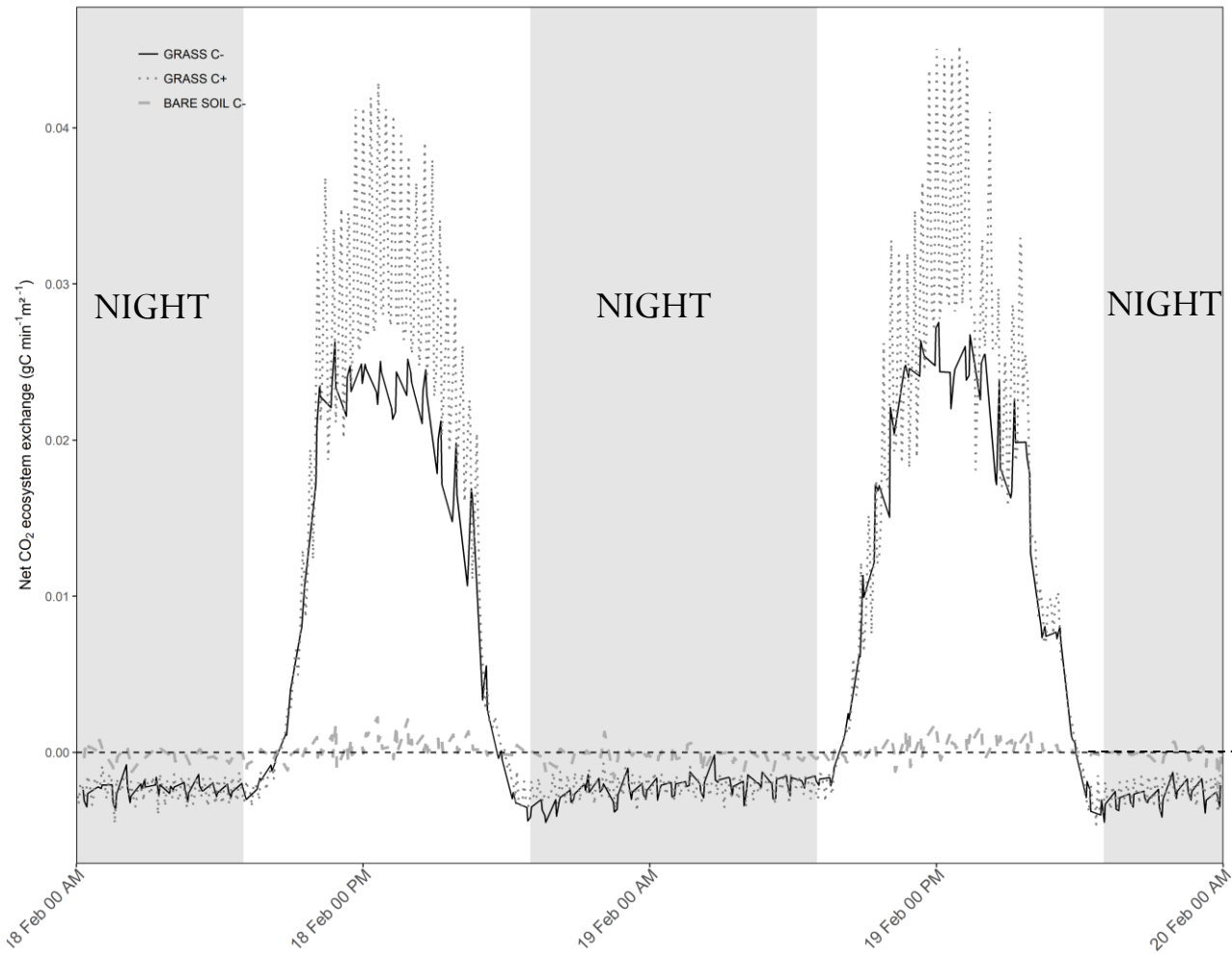




Mesocosms platform with :

- Natural light
- ^{13}C labeling air production
- CO_2 exchanges measurements

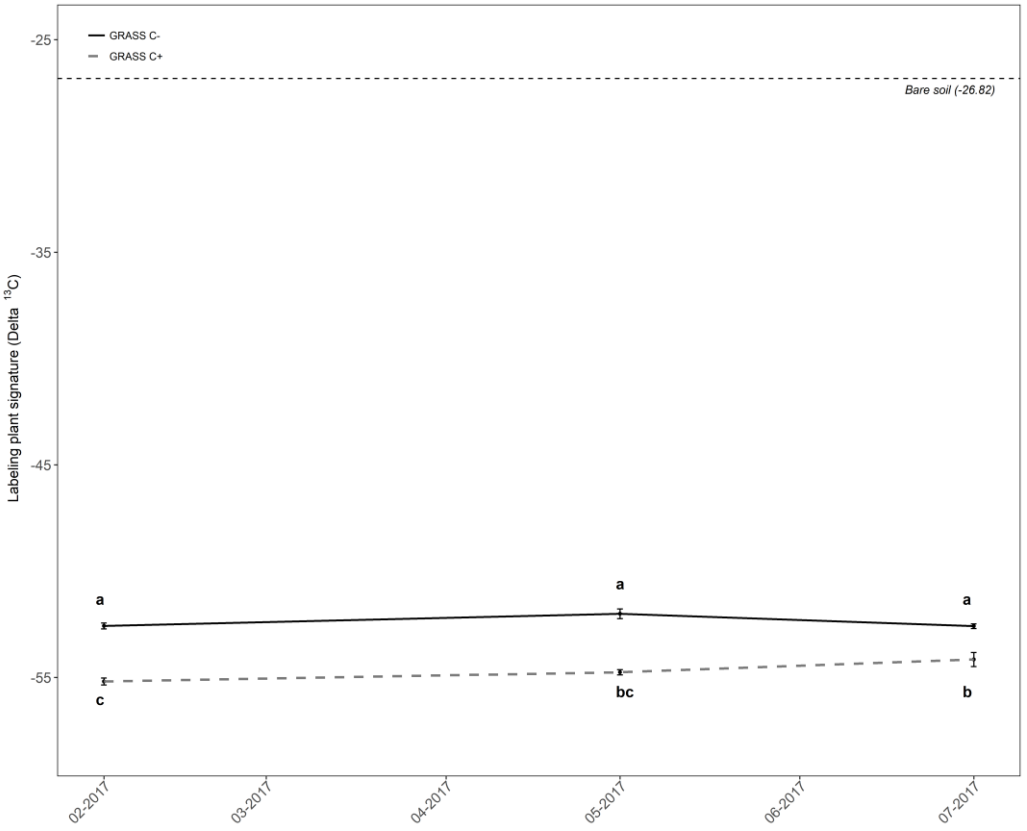
Continuous CO_2 exchanges measurements

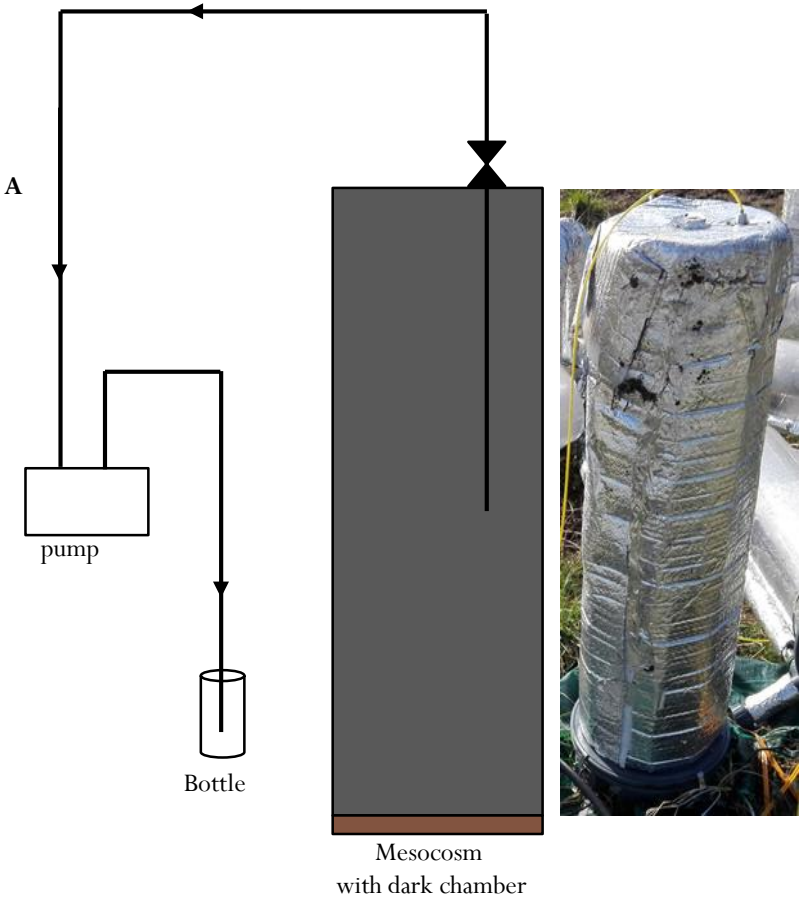


Net Photosynthesis = GPP + ecosytem respiration

Ecosystem respiration

Punctual measurements link to ^{13}C labeling

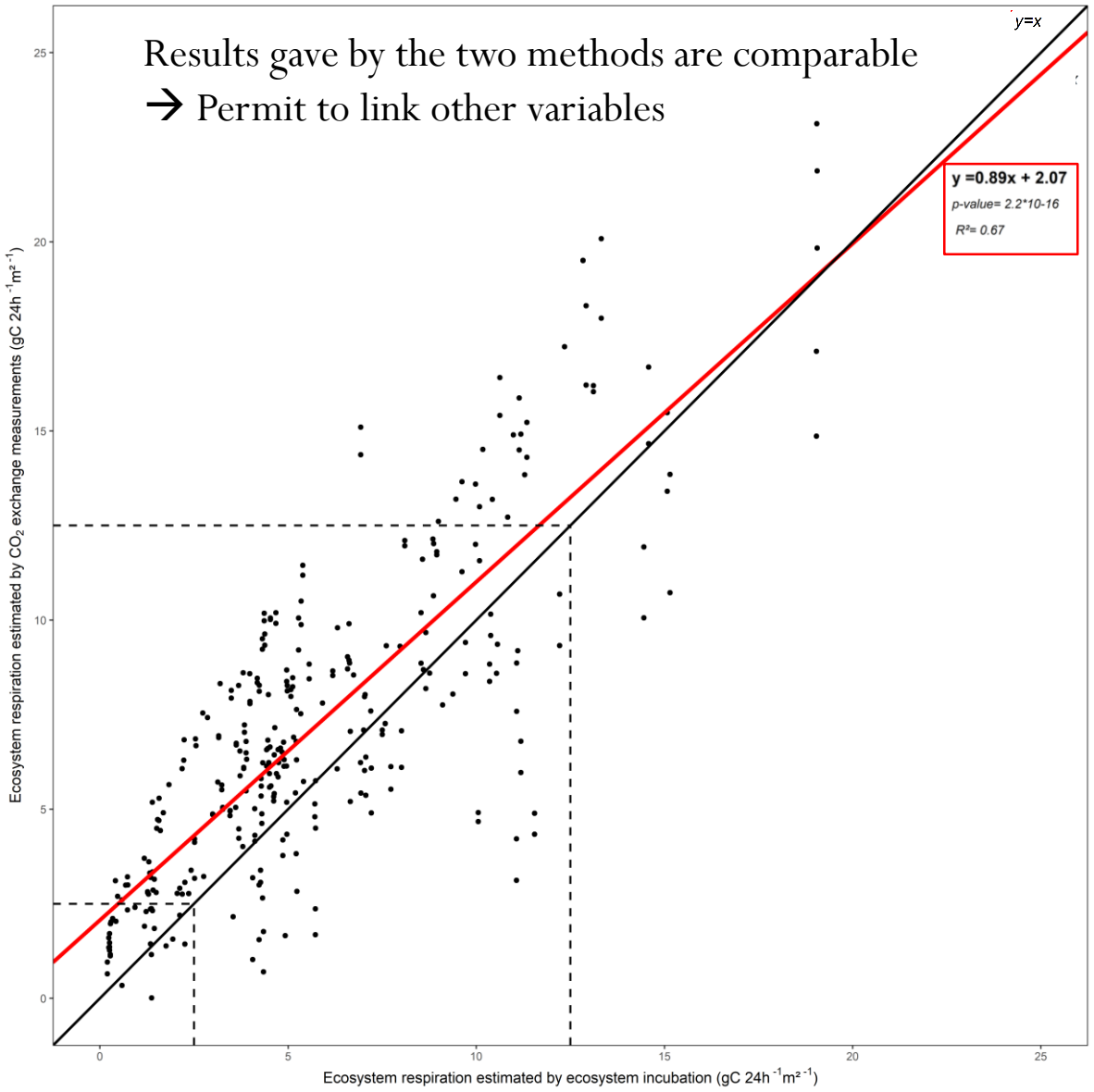




- Permit to measure Ecosystem respiration
- Permit to detect RPE and its dynamics responding to management (mowing), seasons

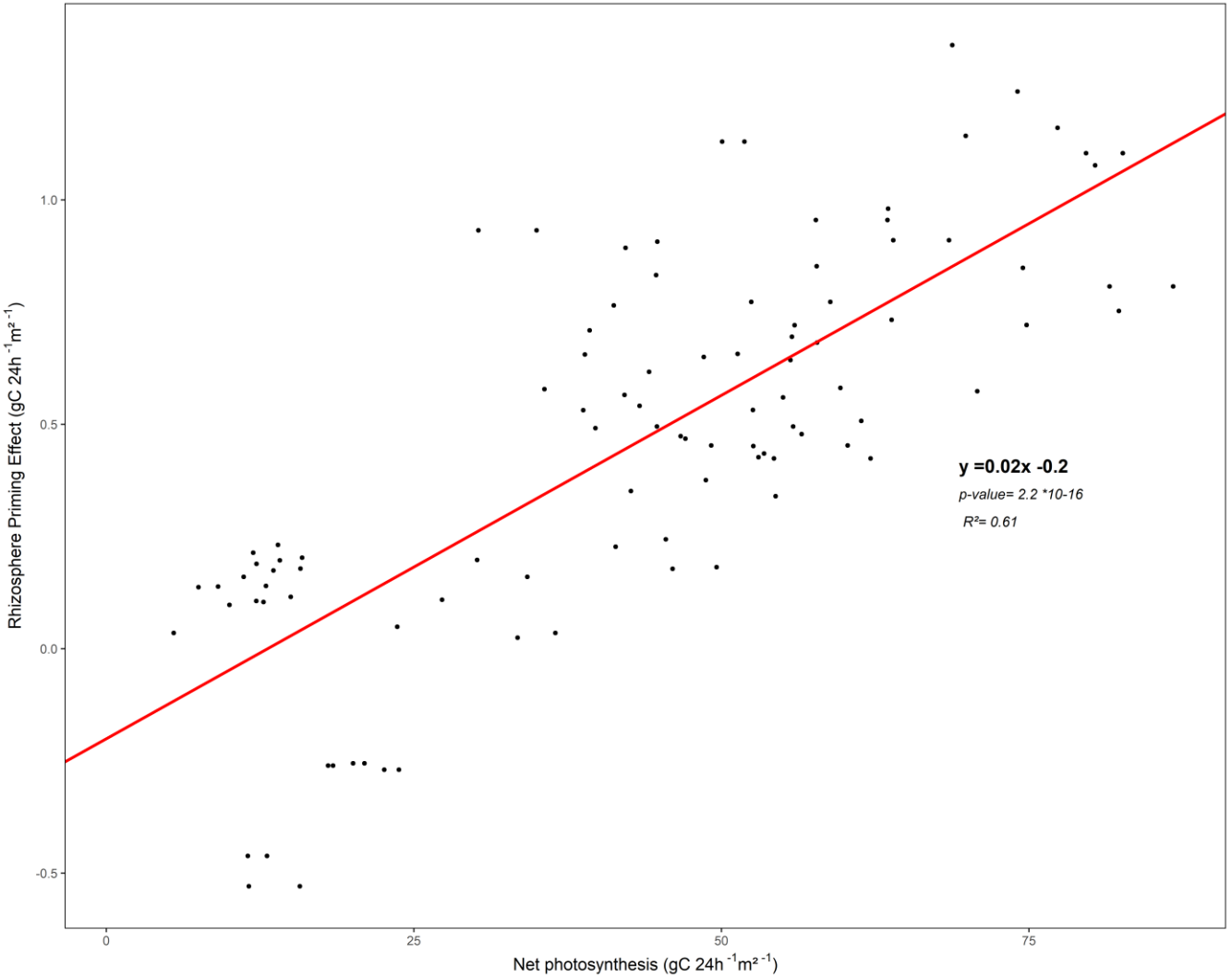
Treatements effects not presented in the paper

Ecosystem respiration measured by the two methods



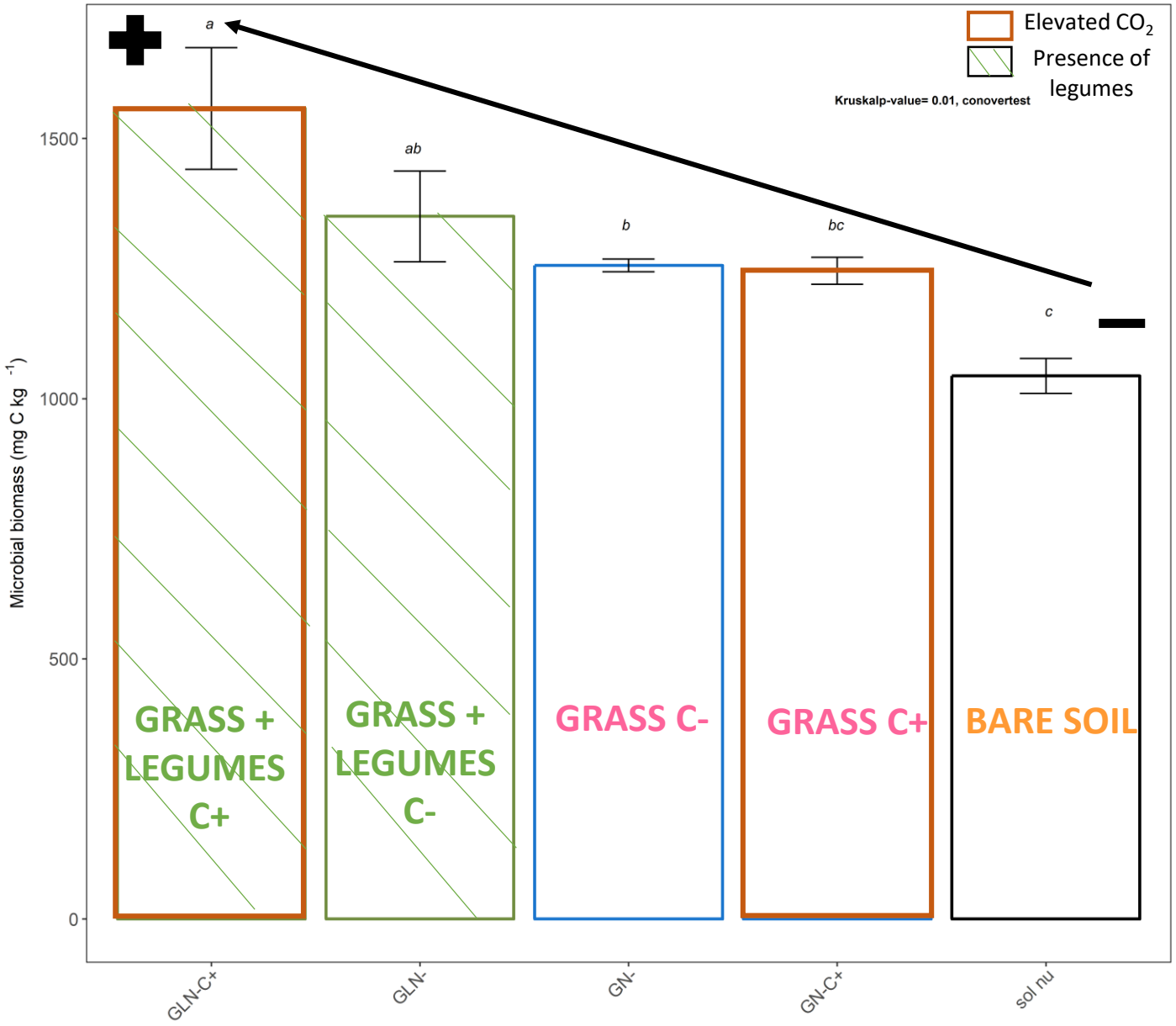
Interesting perspectives:

be abble to estimate RPE through primary production

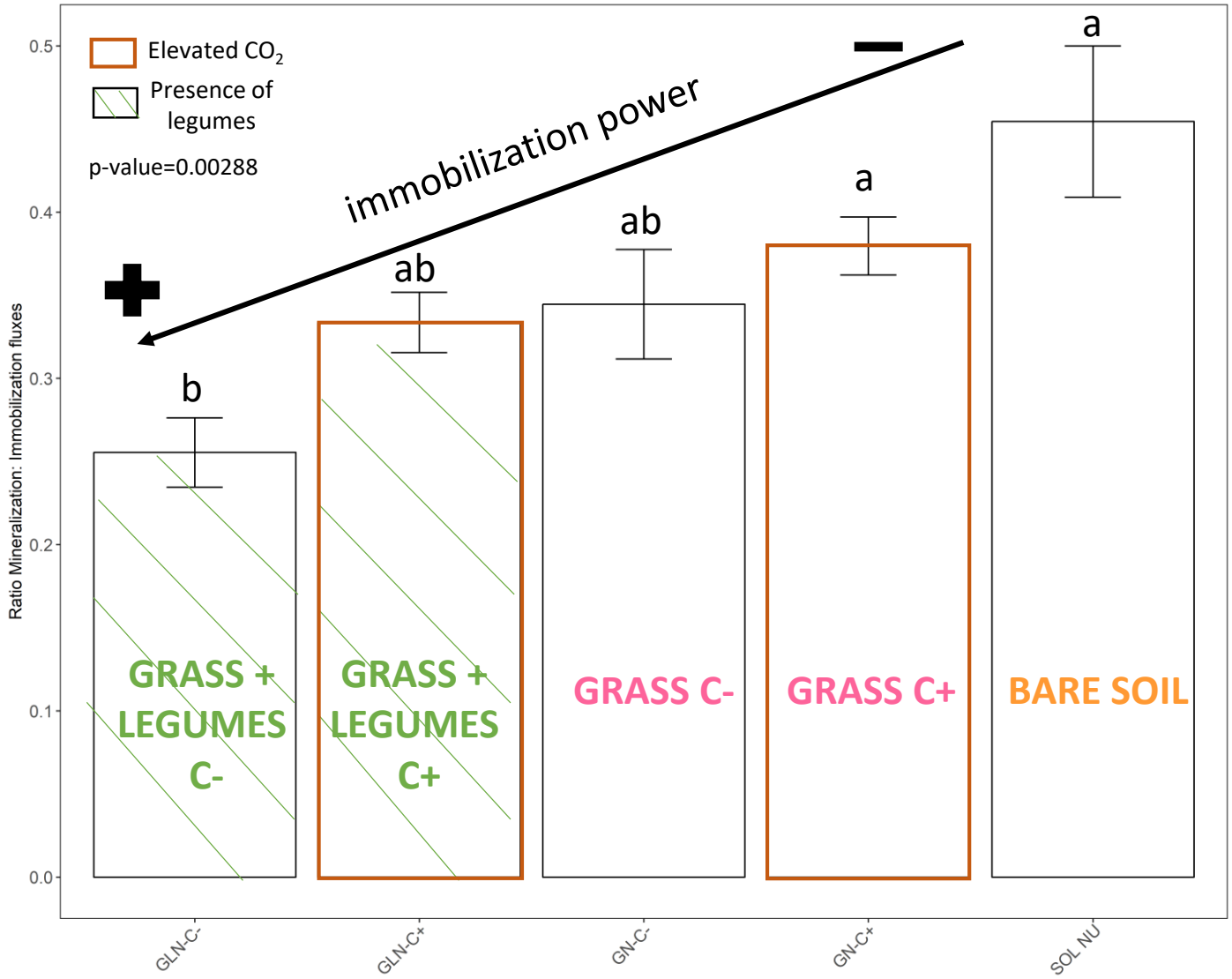



Thanks for your attention ☺

Elevated CO2 effect



News results seems to confirm



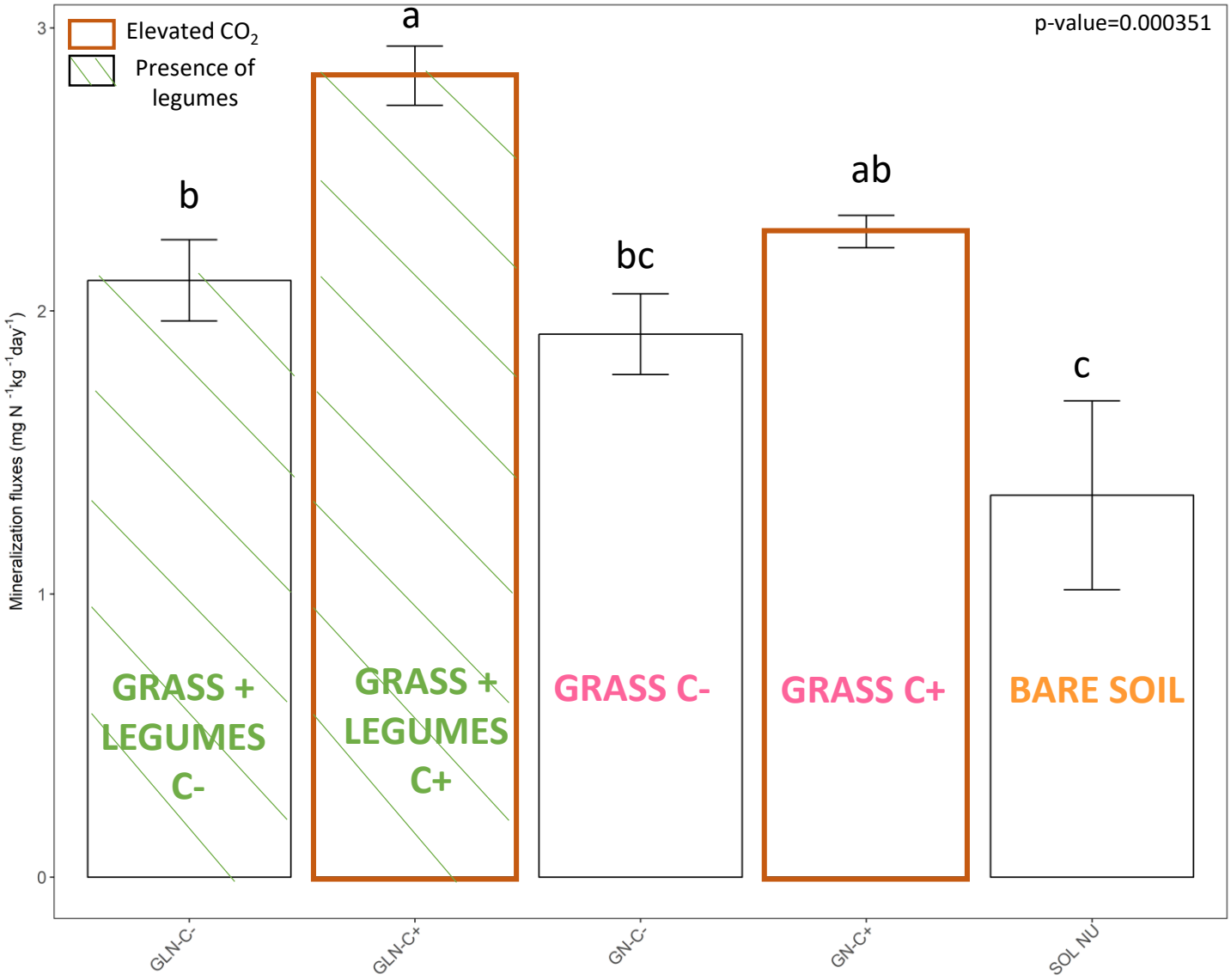
- Less power of imobilization in elevated CO_2
- Gradient of immobilization capacity

→ Higher in presence of legumes

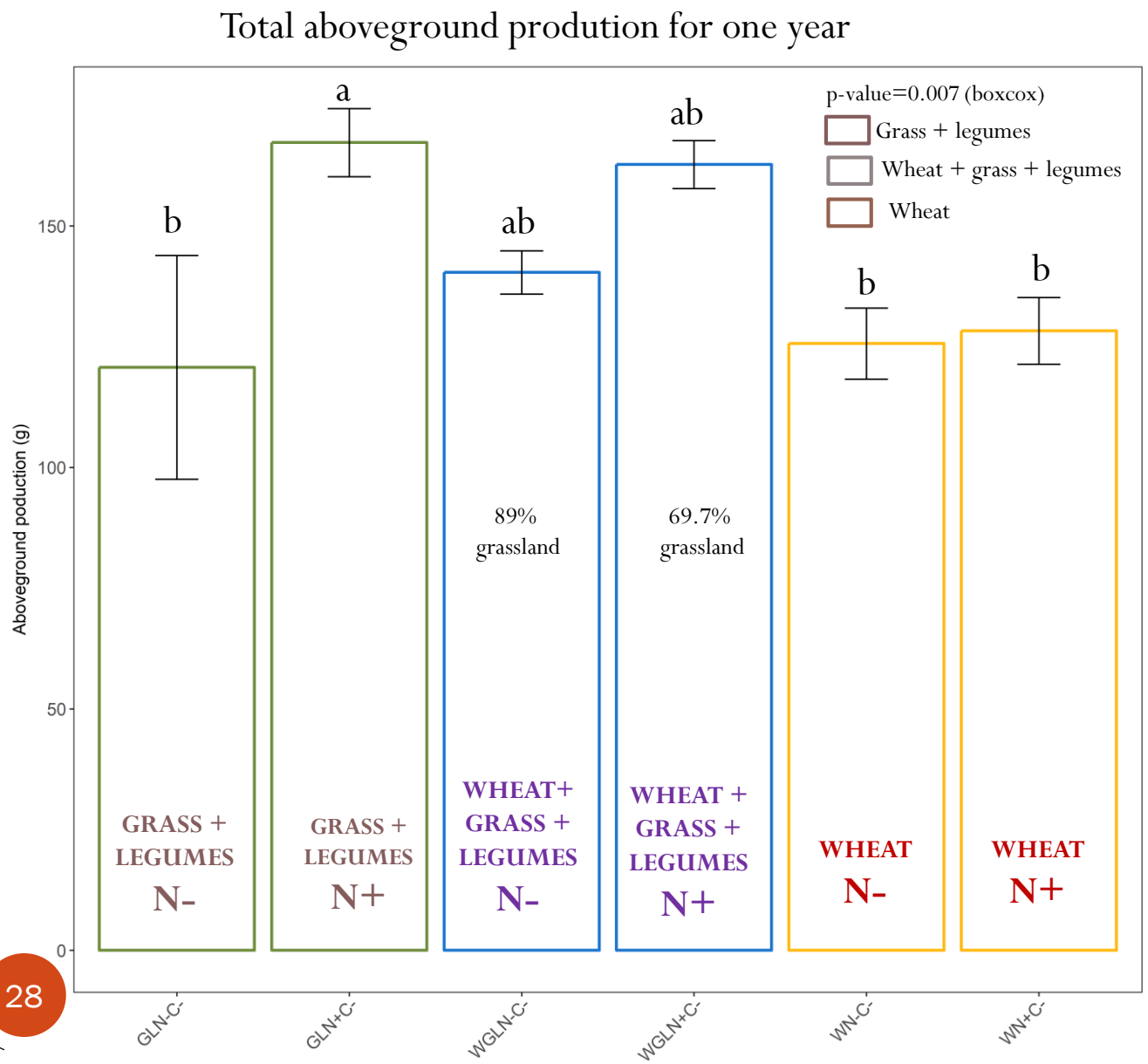
→ Probably higher storage capacity

→ In accordance with previous results

Elevated CO2 effect



Biomass Production



- No effect of N fertilization except in grassland
- Trend: higher production in wheat intercrop compared to monocrop

Land use effect

Yield during one year of production (november 2016 – november 2017)

Treatements	Forage (t DM ha $^{-1}$)	Wheat grain (q ha^{-1})
GRASS + LEGUMES N-	24.87	
GRASS + LEGUMES N+	30.88	
WHEAT + GRASS + LEGUMES N-	25.38	14.82
WHEAT + GRASS + LEGUMES N+	23.18	48.48
WHEAT N-		92.50
WHEAT N+		116.09

- No effect of N fertilization except in grassland

- Trend: higher production in intercropping system