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## Does sulfate addition to soil increase the solubilisation and the availability of cadmium for durum wheat?

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## ➤ Does sulfur addition to soil increase the solubilisation and the availability of Cd?

A. Vidal, C. Nguyen, N. Janot, P. Eon, C. Coriou, J.-Y. Cornu

# > Context



Reduction in atmospheric deposits



Soil S deficiencies



S fertilization on agricultural soils

Protocols Helsinki, 1985, Oslo, 1994, Kyoto, 1997; Arvalis



Sulfur improves cereal quality: grain yield and protein

Tea, 2004



Durum wheat acumulates more Cd in its grain than other cereals

Welch and Norvell, 1999



Regulatory limit: 0.18 mg Cd kg<sup>-1</sup> (EC 1323/2021)



12% of non-compliance in certain French area

Cd



chalcophilic element



strong affinity for S



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# ➤ Cd and S interactions in soils

● → Counter cation

S fertilization: elemental S(0) or sulphate ( $\text{SO}_4^{2-}$ )

## Complexation

↗ [Cd]

McLaughlin, 1999

## Cation exchange desorption

↗ [Cd]

Christensen, 1984

## S oxidation

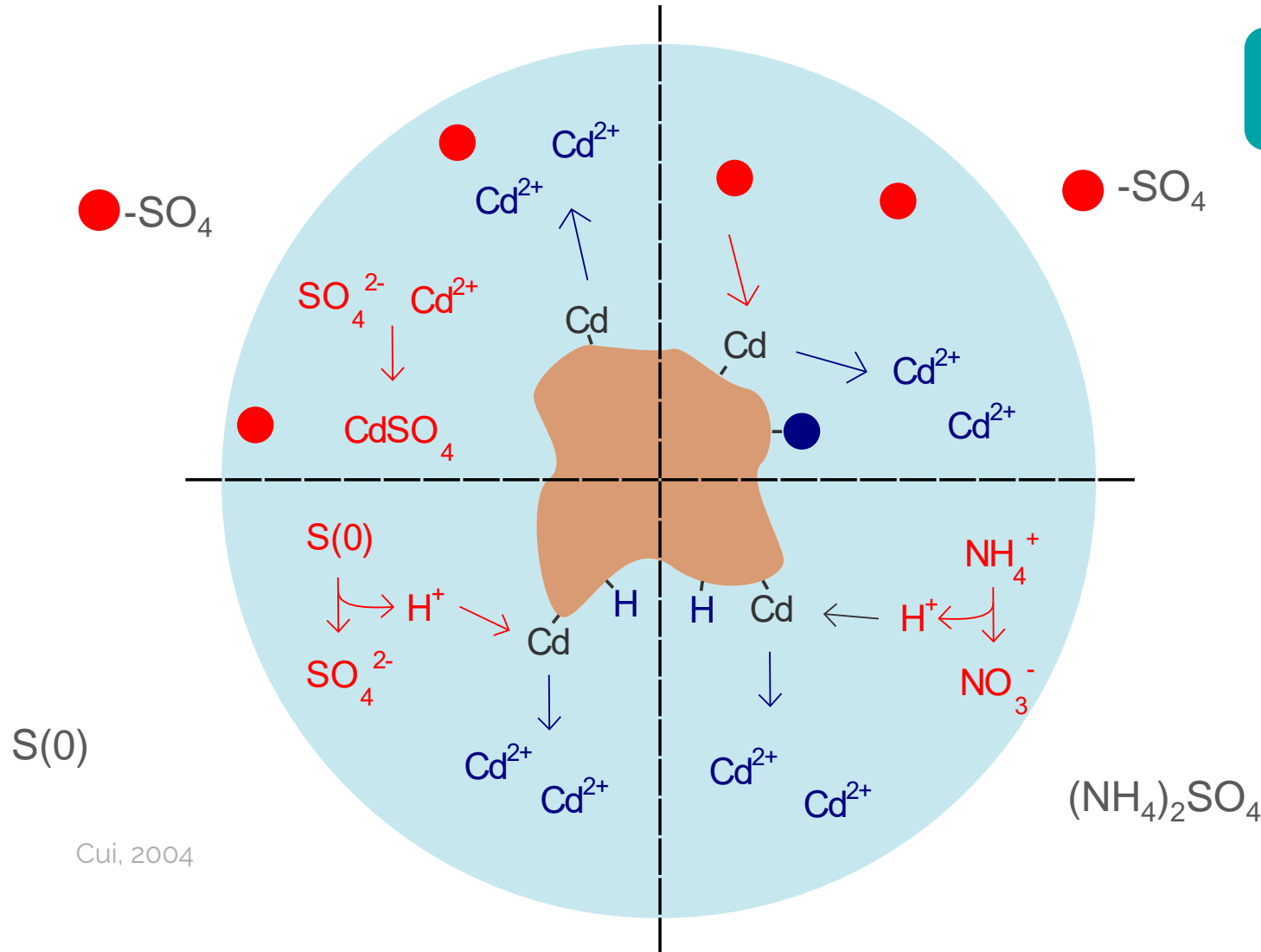
↗ [Cd]

Cui, 2004

## Nitrification

↗ [Cd]

Zaccheo, 2006



## ➤ Objectives and questions

Characterize the effect of S supply at **agronomic forms and doses** on Cd dynamics in soils

- ➔ Does **elemental S** induce Cd solubilisation at **agronomic doses**?
- ➔ Does the addition of  $\text{K}_2\text{SO}_4$  and  $(\text{NH}_4)_2\text{SO}_4$  increase Cd solubility at **agronomic doses**?
- ➔ If so, what are the potential mechanisms?



# > Materials & methods

Two agricultural soils:

- Calcareous clay soil (C)
- Non calcareous loamy soil (NC)

| Clay (%) | Silt (%) | Sand (%) | pH <sub>water</sub> | CaCO <sub>3</sub> (g kg <sup>-1</sup> ) | OM (%) | Cd <sub>total</sub> (mg kg <sup>-1</sup> ) |
|----------|----------|----------|---------------------|-----------------------------------------|--------|--------------------------------------------|
| 66.5     | 24.0     | 9.5      | 8.1                 | 48.9                                    | 4.0    | 1.73                                       |
| 25.9     | 40.3     | 33.8     | 6.9                 | 2.0                                     | 1.4    | 0.12                                       |

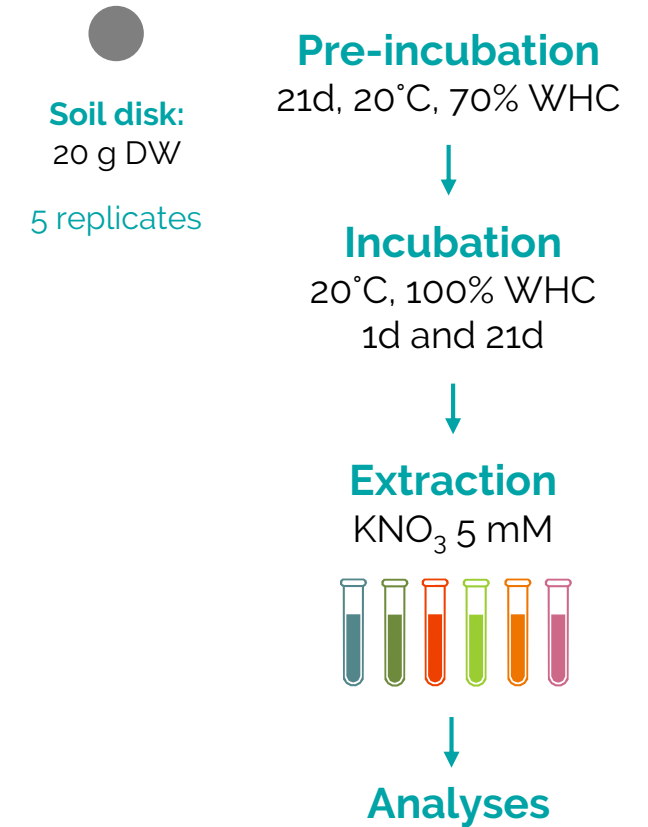


**S-SO<sub>4</sub> and S(o) supply:**

C : 60 kg SO<sub>3</sub> ha<sup>-1</sup>  
 NC : 25 kg SO<sub>3</sub> ha<sup>-1</sup>

**NO<sub>3</sub> control supply:**

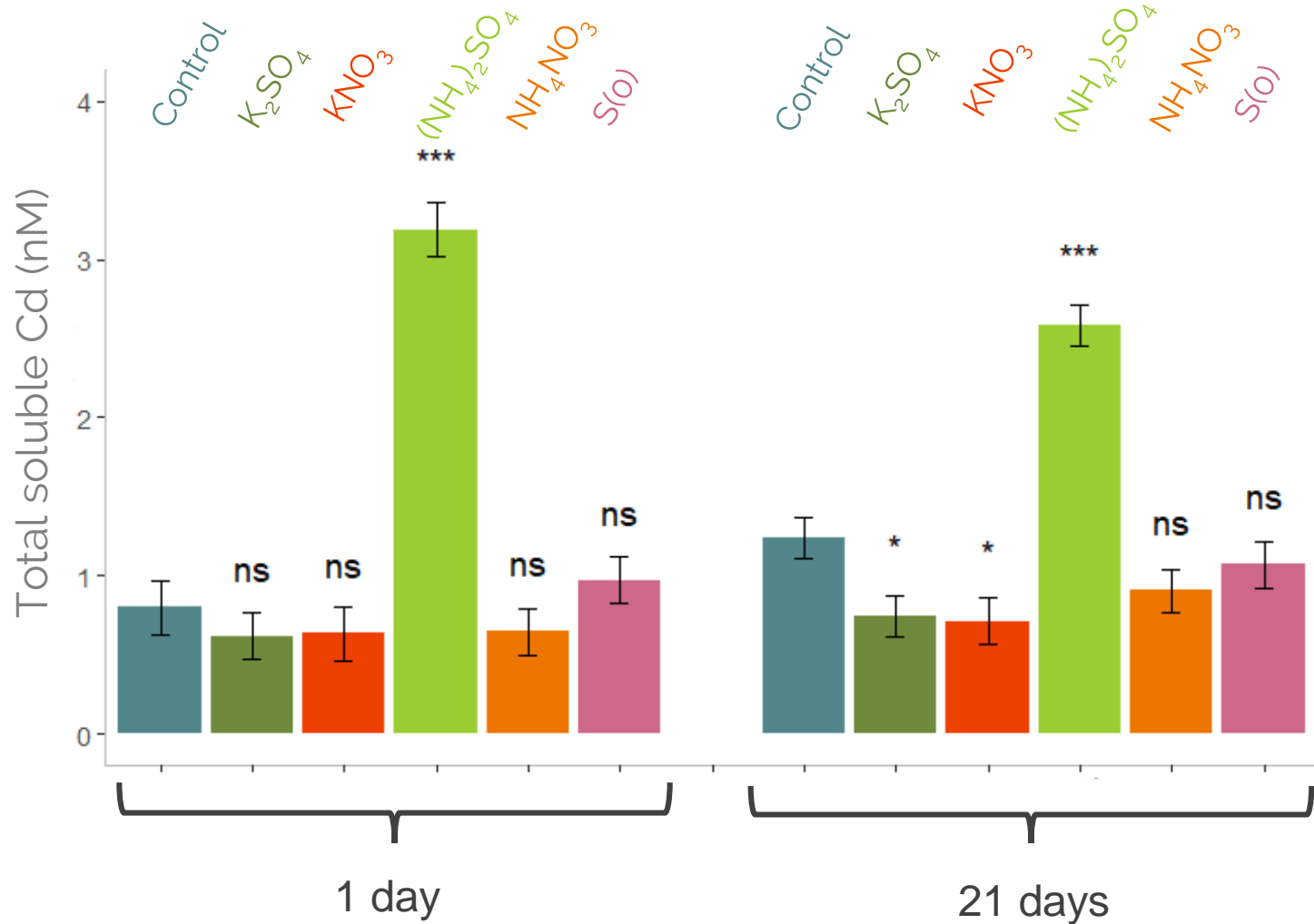
K<sup>+</sup> or NH<sub>4</sub><sup>+</sup> equivalent



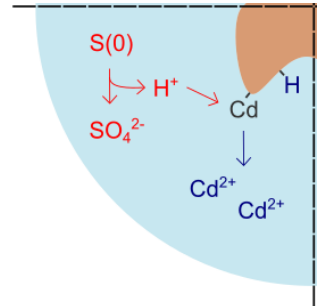
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# ➤ Results

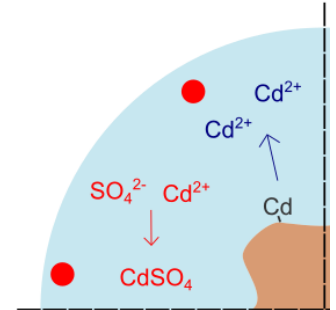
Calcareous soil: total soluble Cd concentrations



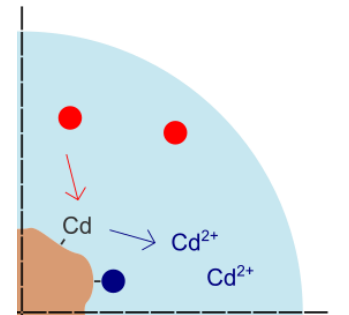
S oxidation



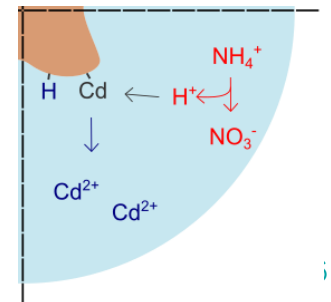
Complexation



Cation exchange desorption

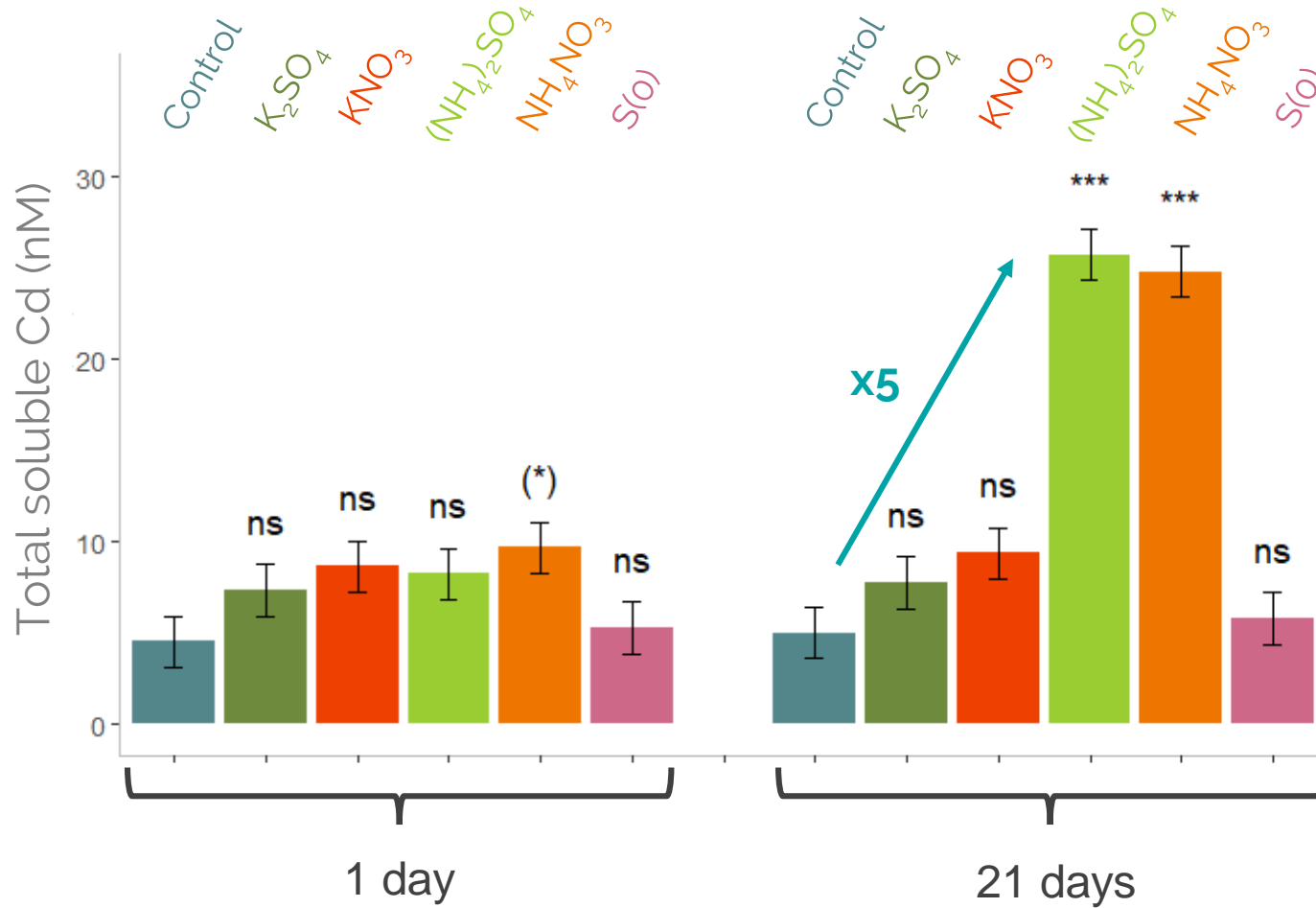


Nitrification



# ➤ Results

Non Calcareous soil: total soluble Cd concentrations



S oxidation



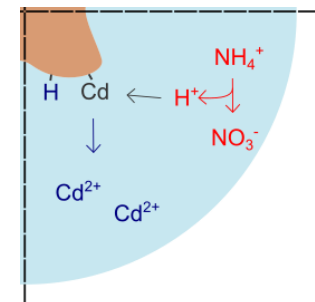
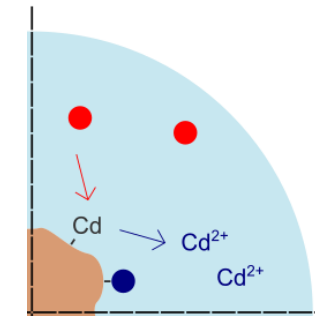
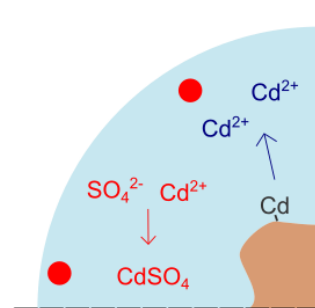
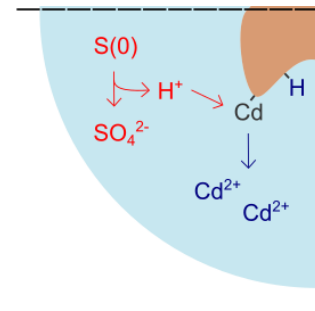
Complexation



Cation exchange desorption



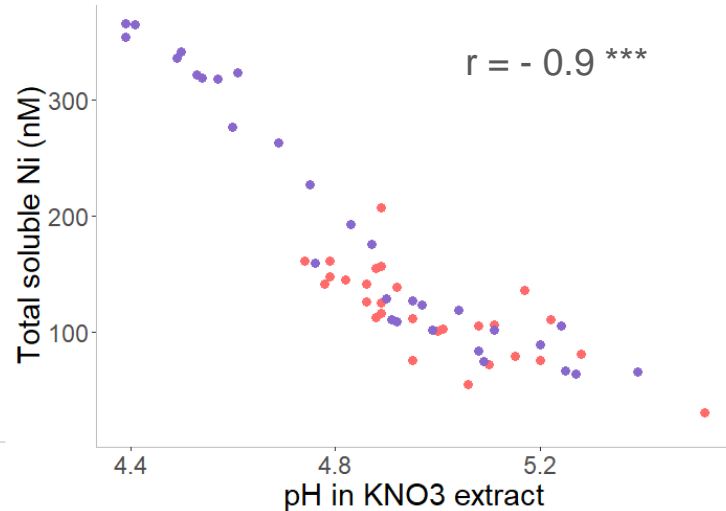
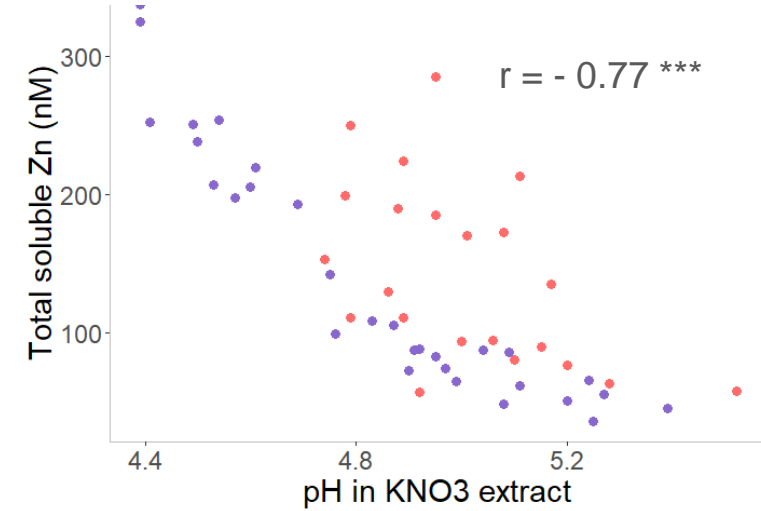
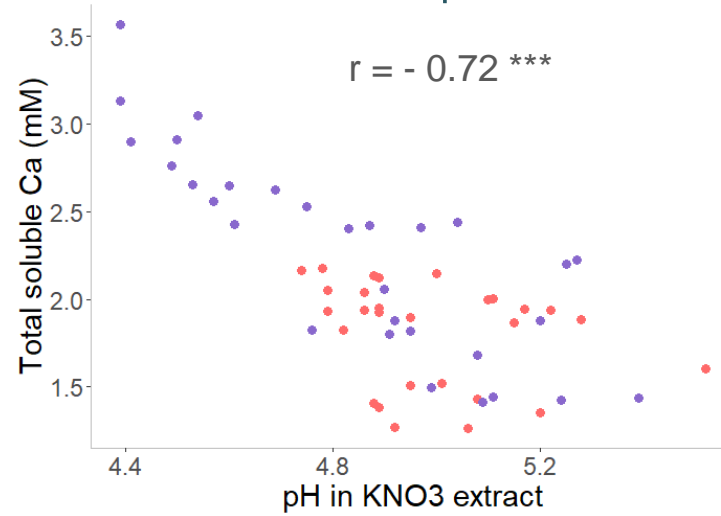
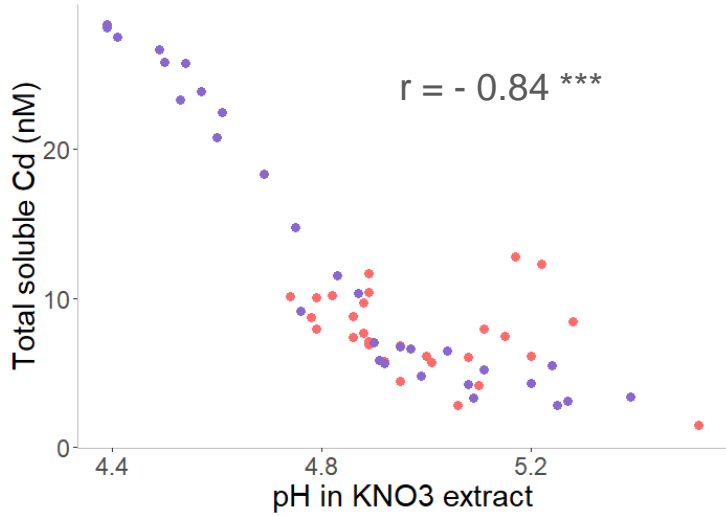
Nitrification



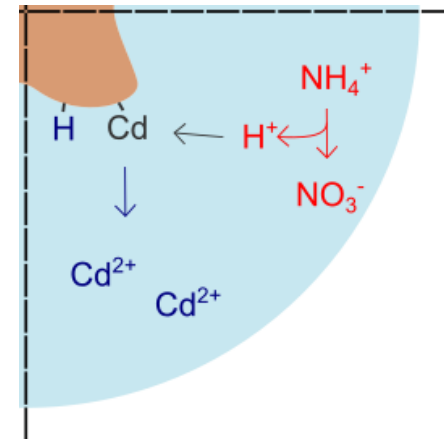


# ➤ Results

Non Calcareous soil: correlations with pH



Desorption by protons produced by nitrification



● 1d ● 21d

## > Conclusion

- At **agronomic doses**, S supplies can solubilize Cd
- Different potential mechanisms for different soils with  $(\text{NH}_4)_2\text{SO}_4$ 
  - Calcareous soil: by a mechanism other than those tested
  - Non calcareous soil: multiplies by 5 the Cd total soluble

Nitrification



Production of protons



Cd desorption

**Beware of  $\text{NH}_4$  forms of sulfate when fertilizing, particularly for durum wheat crops**

➤ Thank you for your attention



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Does sulfur addition to soil increase the solubilisation and the availability of Cd?  
Friday, September 8<sup>th</sup> 2023 / ICOBTE-ICHMET / A. Vidal