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

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Fundings for the conference:

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

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Soil S deficiencies

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S fertilization on agricutural 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^{-1} (EC 1323/2021)

12% of non-compliance in certain French area

Cd → chalcophilic element → strong affinity for S

Cd and S interactions in soils

S fertilization: elemental S(0) or sulphate (SO_4^{2-})

● → Counter cation

Complexation

● -SO_4

↗ [Cd]

McLaughlin, 1999

Cation exchange desorption

● -SO_4

↗ [Cd]

Christensen, 1984

S oxidation

↗ [Cd]

S(0)

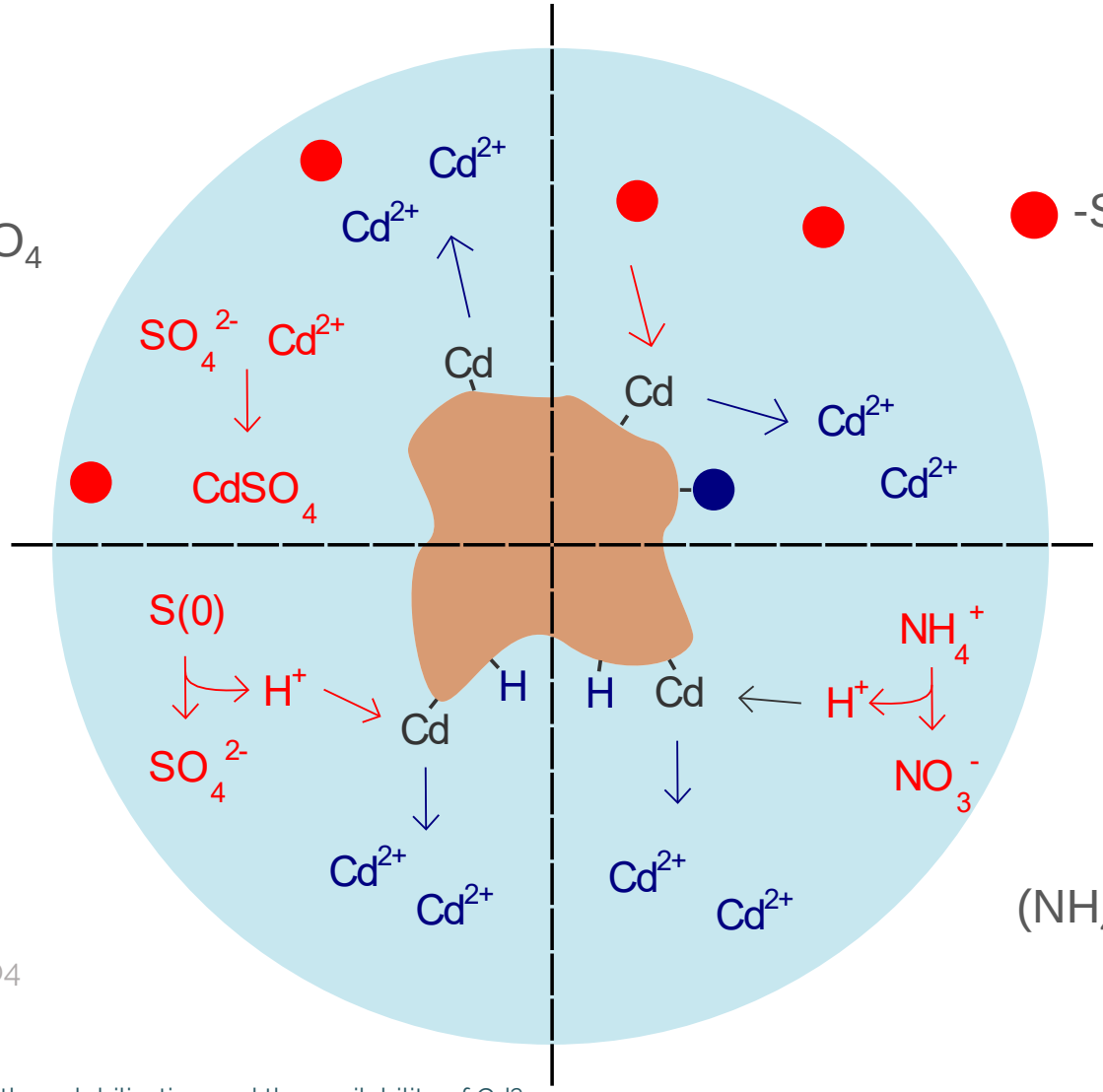
Cui, 2004

Nitrification

↗ [Cd]

$(NH_4)_2SO_4$

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 **K_2SO_4** and **$(NH_4)_2SO_4$** increase Cd solubilty 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_{water}	$CaCO_3$ (g kg^{-1})	OM (%)	Cd_{total} (mg kg^{-1})
C	66.5	24.0	9.5	8.1	48.9	4.0	1.73
NC	25.9	40.3	33.8	6.9	2.0	1.4	0.12

Soil disk:
20 g DW

5 replicates

Pre-incubation
21d, 20°C, 70% WHC

Incubation
20°C, 100% WHC
1d and 21d

Extraction
KNO_3 5 mM

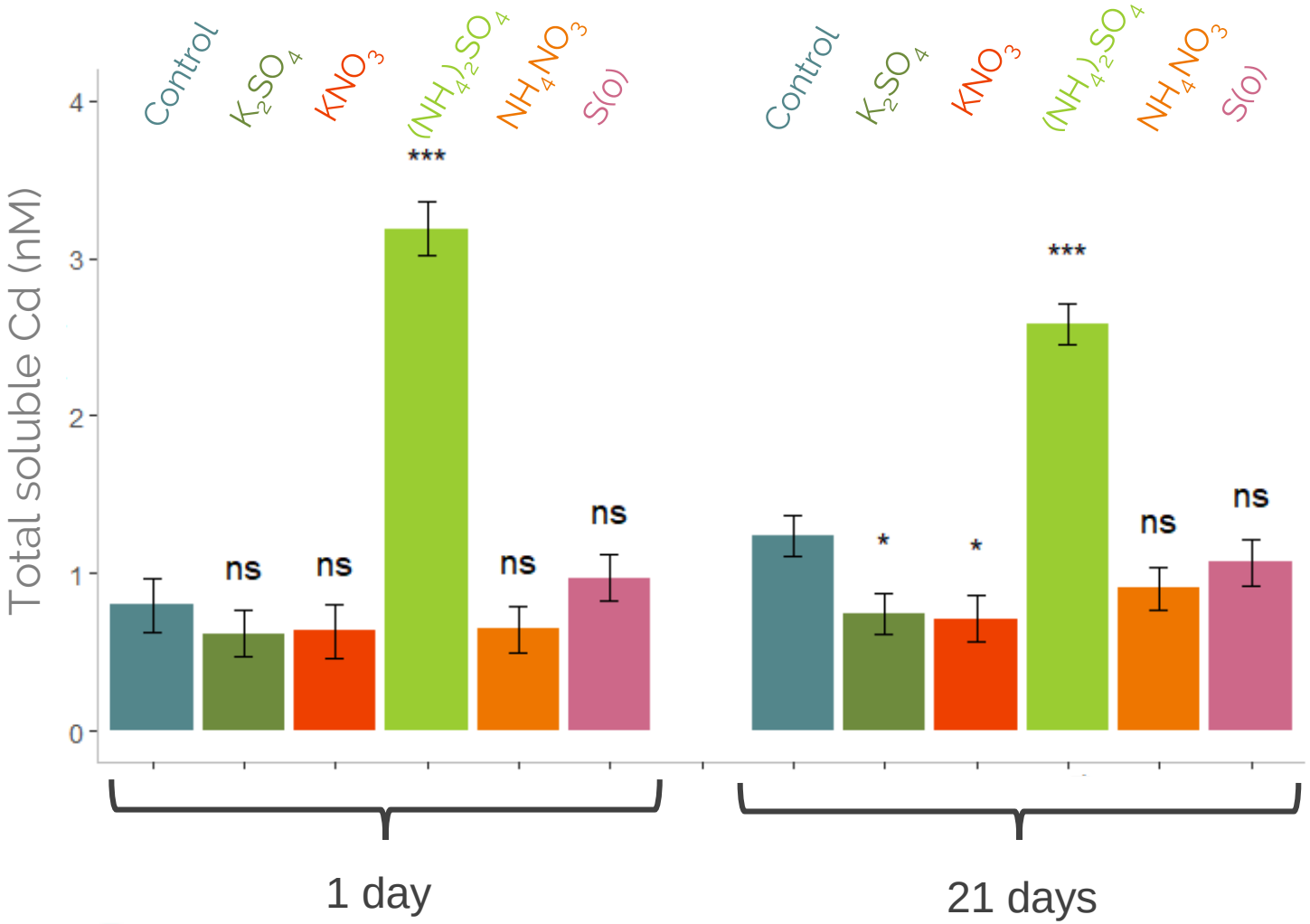
Analyses

$S\text{-}SO_4$ and S(0) supply:
C : 60 kg SO_3 ha^{-1}
NC : 25 kg SO_3 ha^{-1}

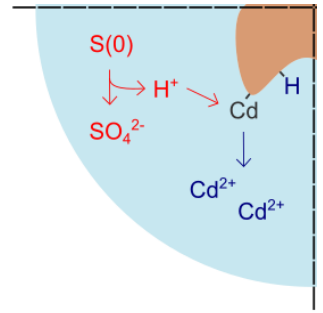
NO_3 control supply:
K^+ or NH_4^+ equivalent

Results

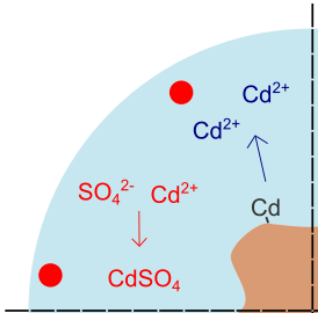
Calcareous soil: total soluble Cd concentrations



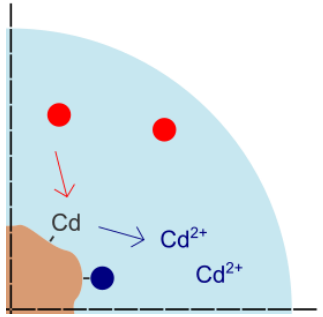
S oxidation ✗



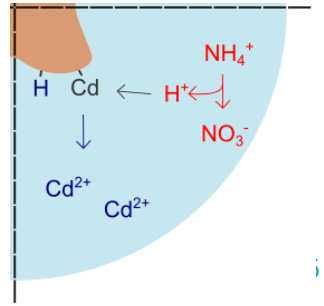
Complexation ✗



Cation exchange desorption ✗

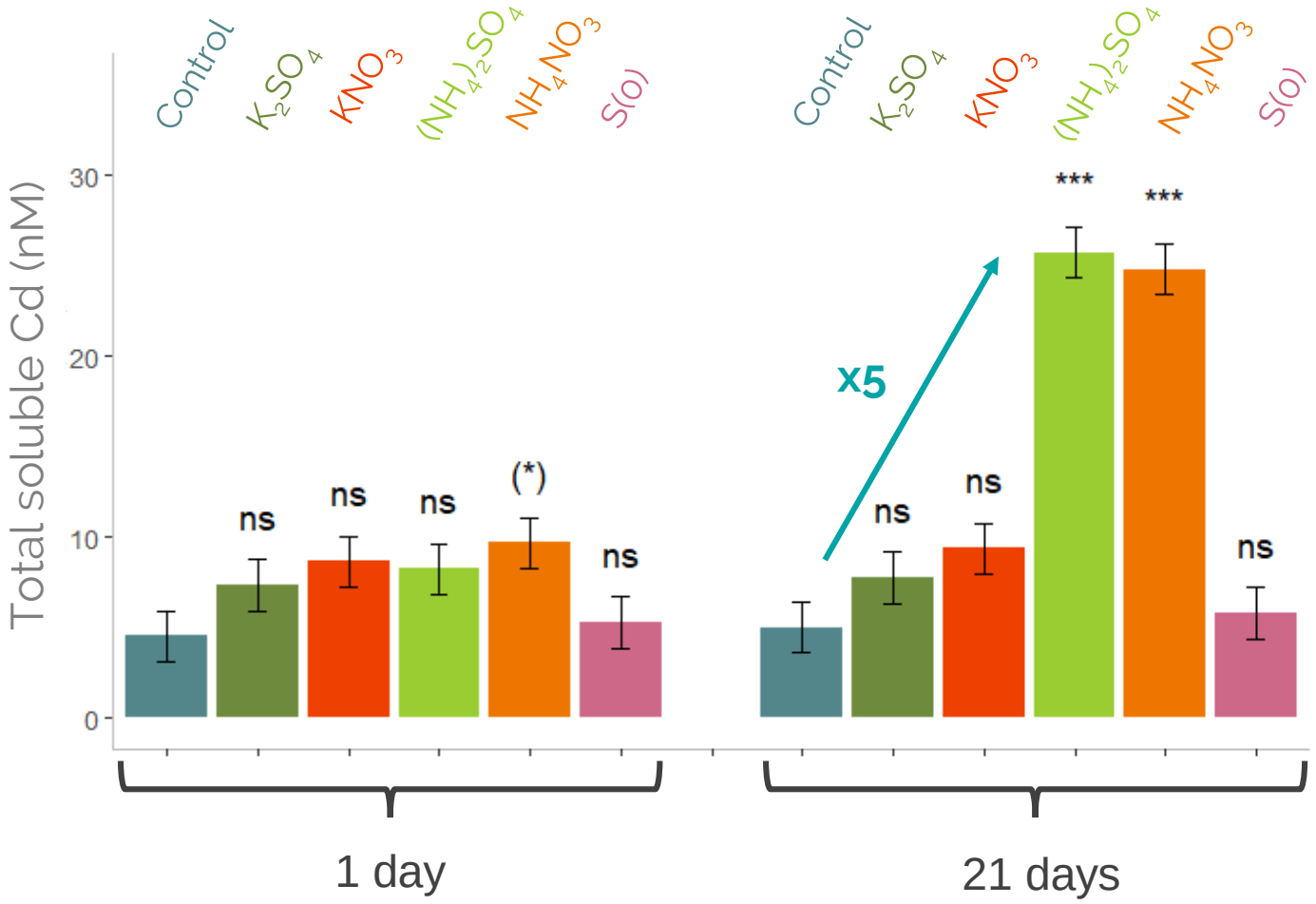


Nitrification ✗

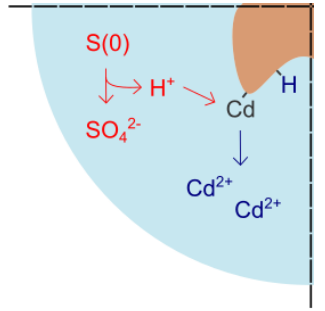


Results

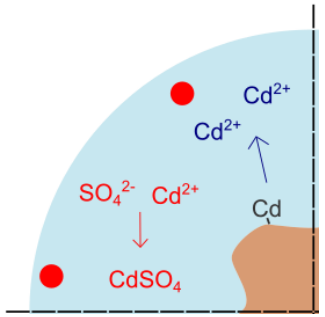
Non Calcareous soil: total soluble Cd concentrations



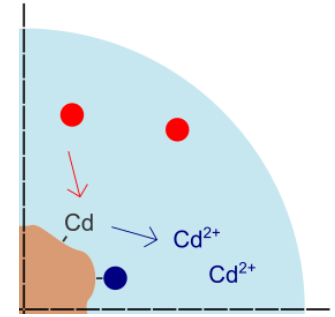
S oxidation



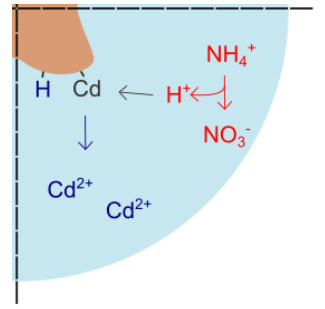
Complexation



Cation exchange desorption



Nitrification



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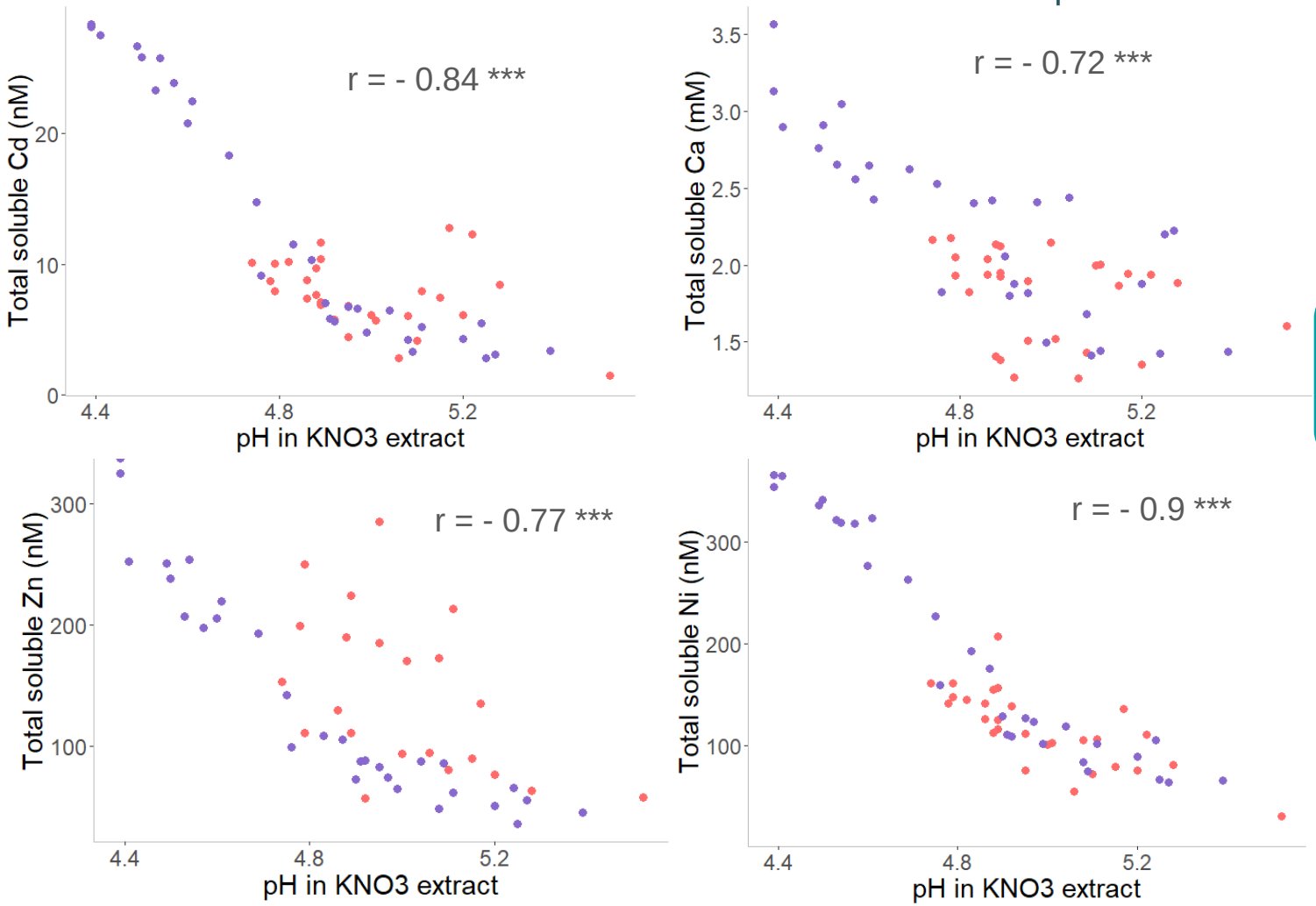
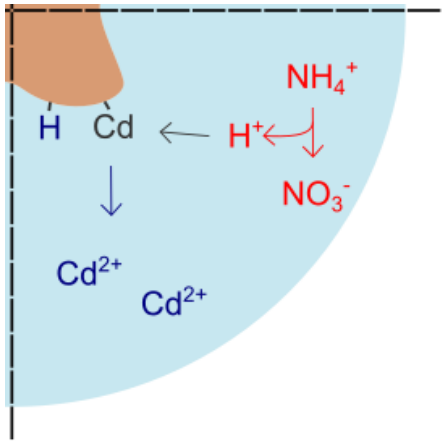
Results

Non Calcareous soil: correlations with pH



Desorption by protons produced by nitrification



Conclusion

→ At **agronomic doses**, S supplies can solubilize Cd

→ Different potential mechanisms for different soils with $(NH_4)_2SO_4$

- ↪ 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 NH_4 forms of sulfate when fertilizing, particulary for durum wheat crops

Thank you for your attention