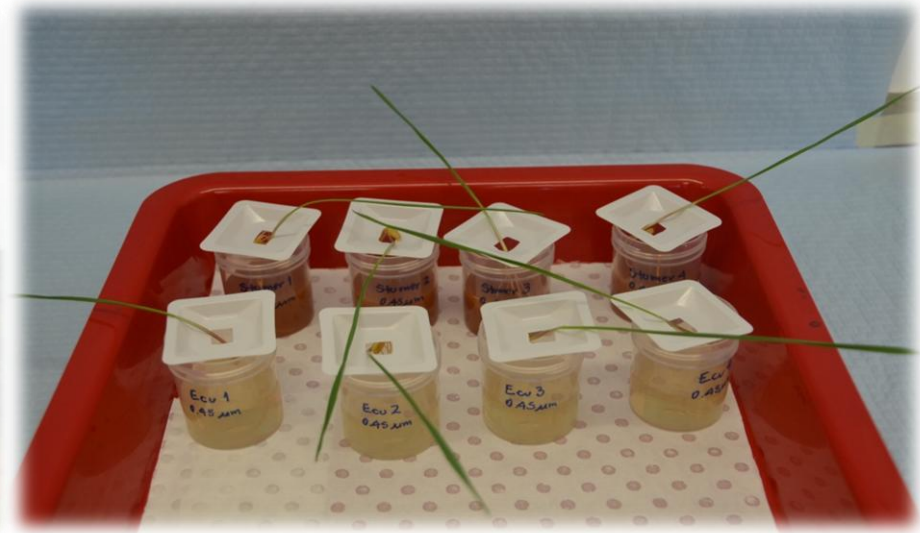




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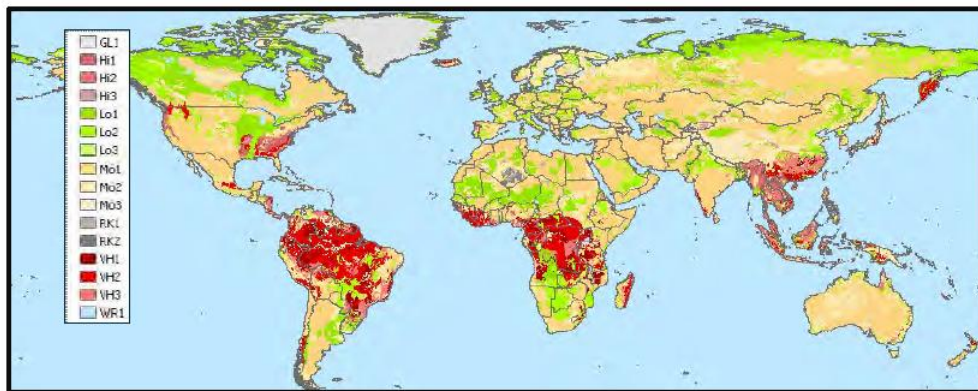


# Colloidal phosphorus contributes to plant nutrition

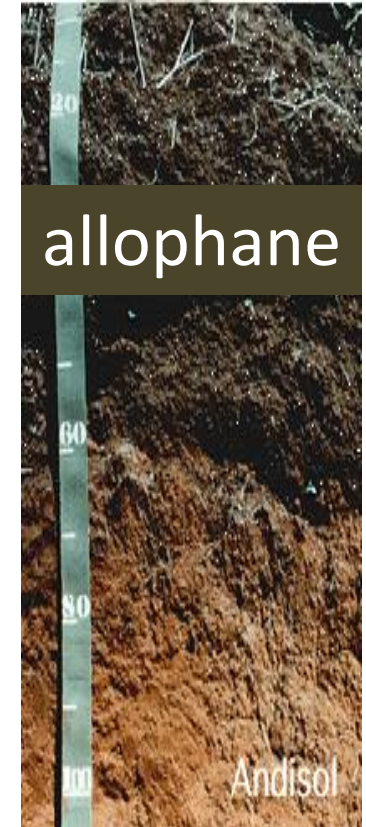
Daniela Montalvo, Fien Degryse, Mike McLaughlin

# Andisols and Oxisols: highly P-sorbing soils

- P strongly bound to high P-sorbing minerals
- P unavailable to plants
- Highly P-sorbing soils mainly found in Africa, South America



(Batjes 2011)



(Uehara et al. 2001)

# Phosphorus in soils



Solid-phase (>90% of soil P)

Solution-phase ( $\mu\text{M}$ )

- $\text{H}_2\text{PO}_4^-$   $\text{HPO}_4^{2-}$  (plant-available P)
- Mobile colloidal P complexes (P-Fe/Al/C of size range: 1-1000 nm)

# Soil-solution phosphorus

- Bioavailability of soil-solution P related to:
  - concentration
  - speciation
- Membrane filtration (0.45  $\mu\text{m}$ ) operationally differentiates “*particulate*” and “*dissolved*” P
- Colloidal P < 0.45  $\mu\text{m}$  has been reported
- Natural colloidal P may play a role in plant nutrition, yet has not been considered

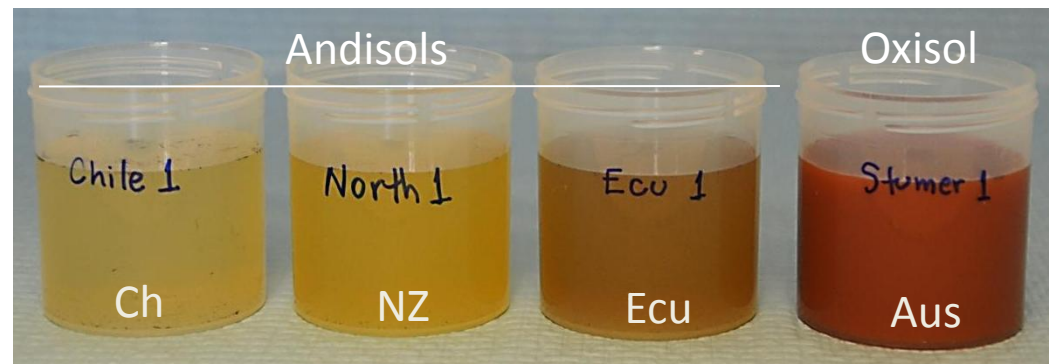
# Research question

- Synthetic P-loaded  $\text{Al}_2\text{O}_3$  nanoparticles used as mobile P buffer enhanced the uptake of P by *Brassica napus* with increasing P buffering at low free P concentration (Santner et al. 2012)
- Colloidal P can comprise a large amount of total solution P in Andisols and Oxisols

Is colloidal P from Andisols and Oxisols  
plant available?

# Solutions for plant P uptake experiment

- 1:10 soil-water extracts from Andisols (3) & Oxisol (1) obtained by centrifugation
- Soil-solutions spiked with  $^{33}\text{P}$  and equilibrated for 3 days
- Radiolabeled solutions divided in fractions:
  - Non-filtered (NF)
  - 0.45  $\mu\text{m}$
  - 3 kDa





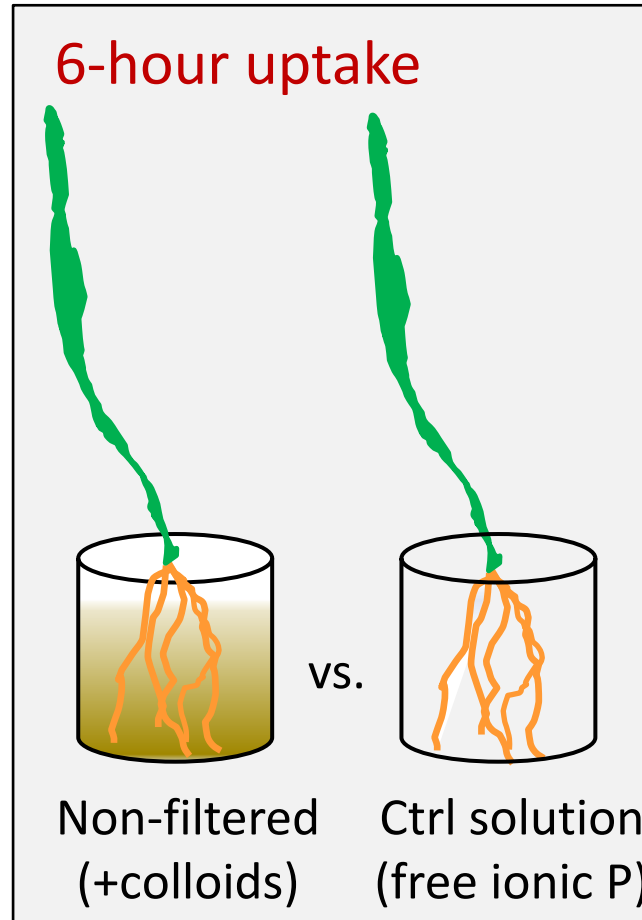
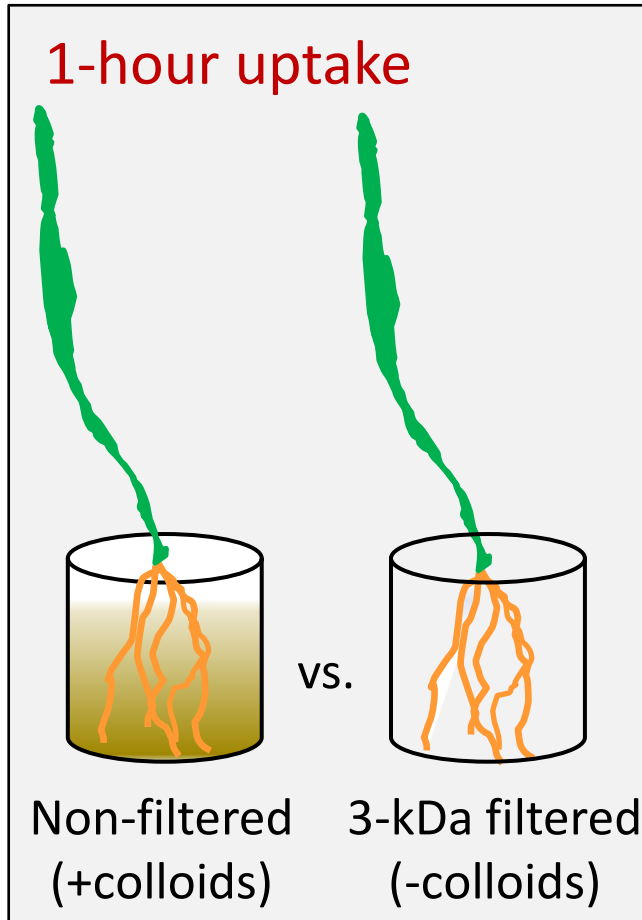
# Colloidal P in the uptake solutions

- P associated with Al/Fe
- Different nature of colloidal P between soil groups:

Molar ratio	Al:P	Fe:P
Andisols	16-34	2-7
Oxisol	165	60

- $^{33}\text{P}$  activities of soil-water extracts significantly decrease with filtering: NF  $\gg$  0.45  $\mu\text{m}$   $>$  3 kDa
  - Size range of colloids: Andisols 30-240 nm and Oxisols 10-60 nm (high speed disk centrifuge)
-

# Short-term plant P uptake experiments



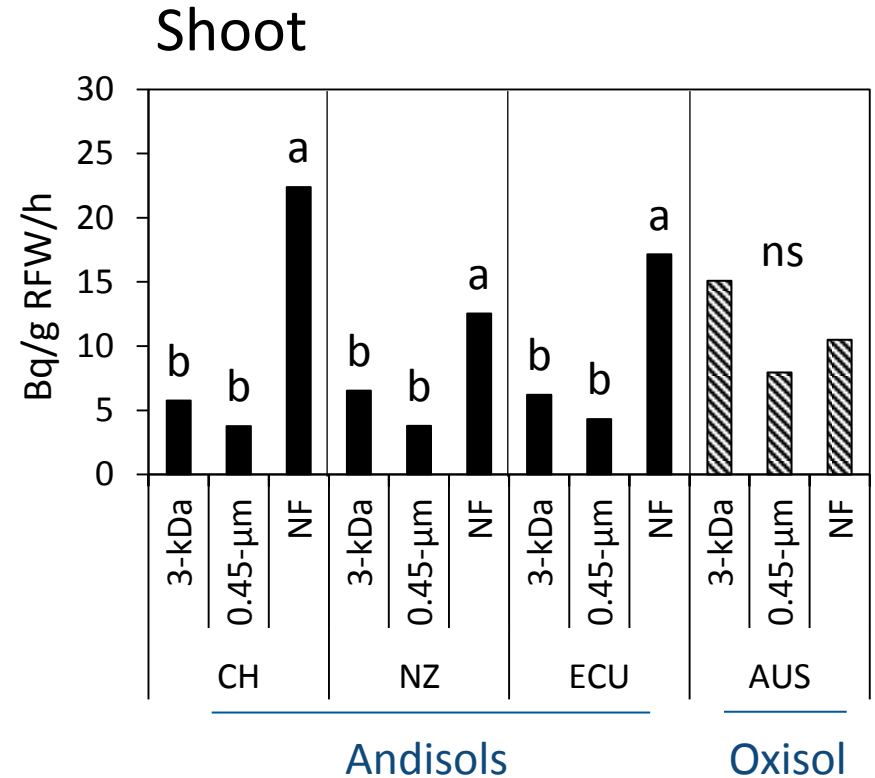
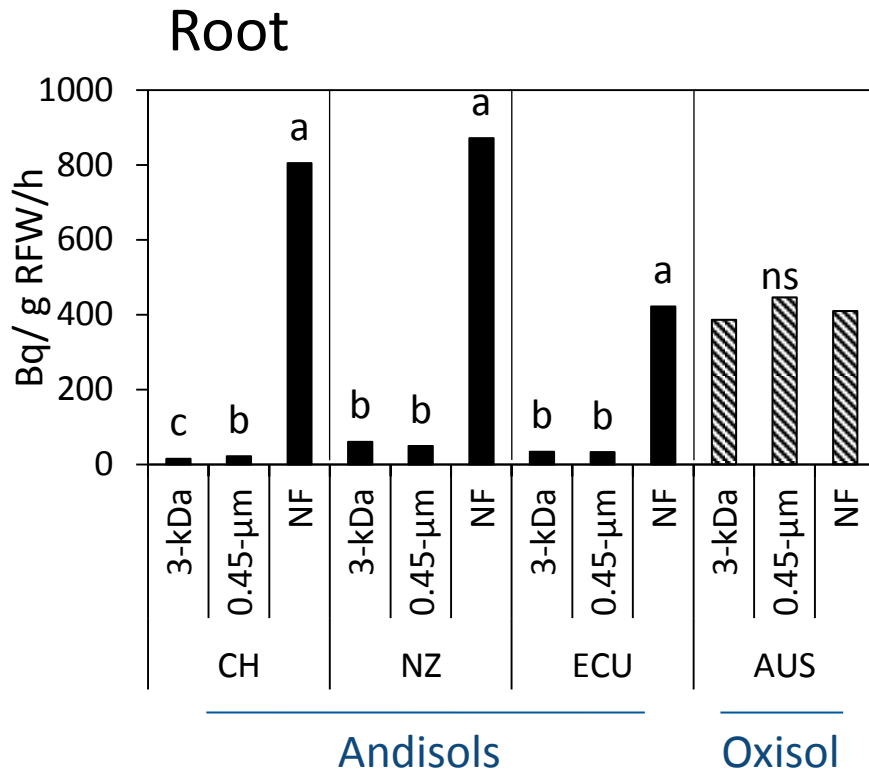
## Analysis

- Shoot/root acid extracted
- $^{33}\text{P}$  activity measured in plant extracts and uptake solutions

Similar findings  $\Rightarrow$  only results of 1-hour uptake experiment discussed

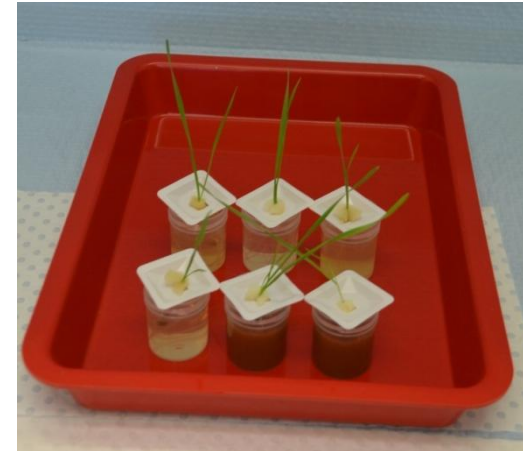
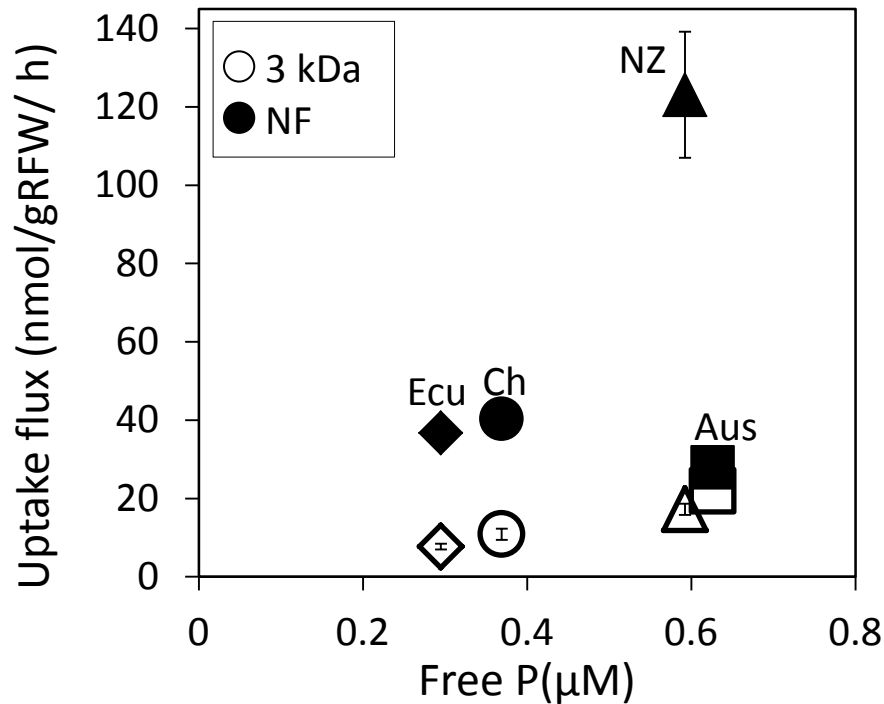


# $^{33}\text{P}$ activity in shoot and root



Significantly higher  $^{33}\text{P}$  activity in shoots from plants exposed to NF solutions indicates true absorption followed by translocation

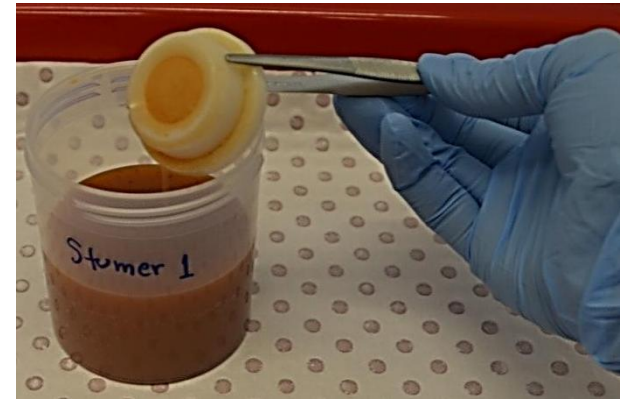
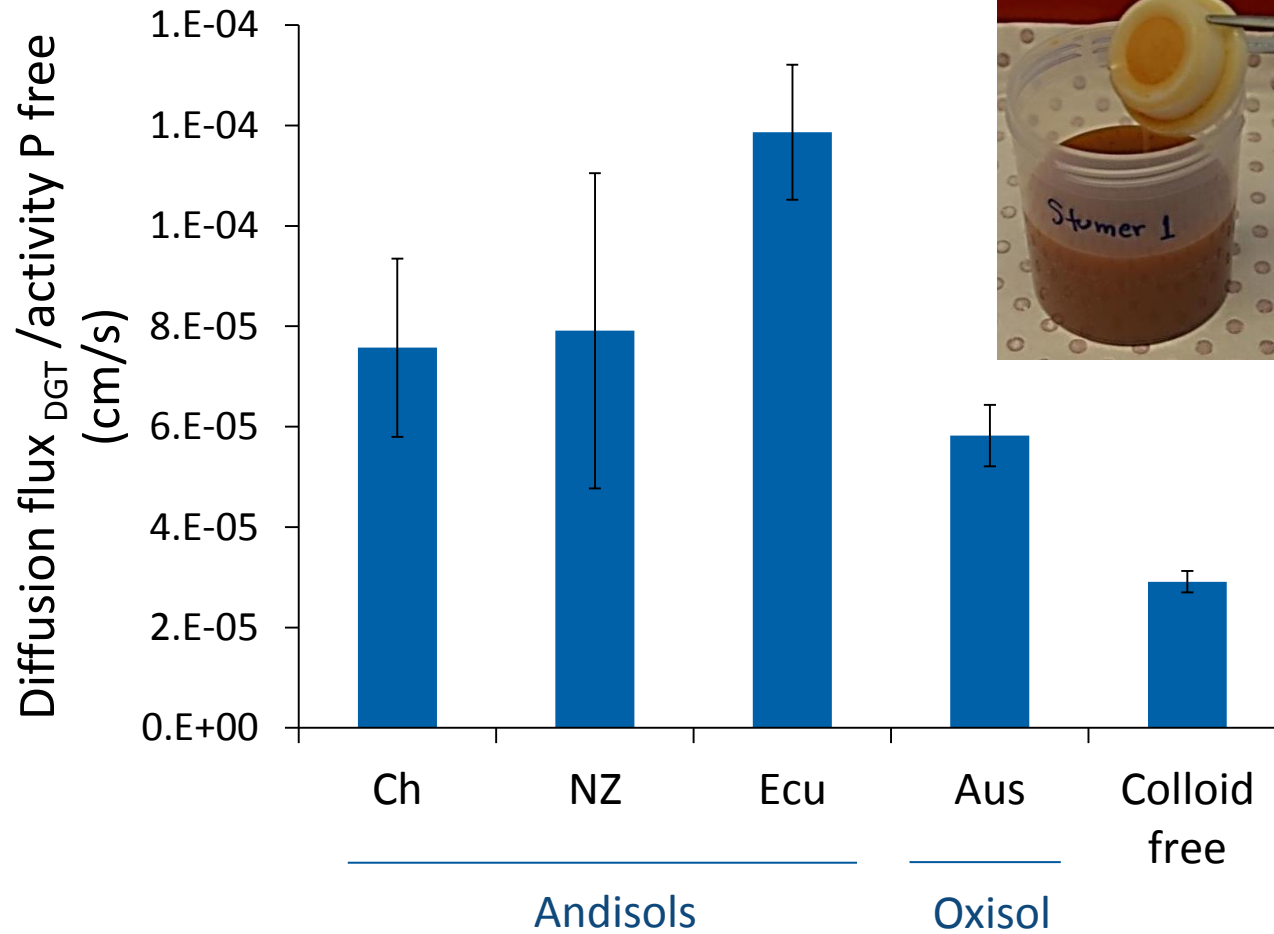
# Uptake fluxes: non-filtered vs. 3-kDa filtered



	NZ	Solution P (μM)	Uptake flux (nmol/g/h)
NF		30	123
3 kDa		0.6	17
Ratio		50	7

- Uptake flux from NF solutions (Andisol) up to 7-fold higher than the 3 kDa filtered solution (at same free P concentration)

# P diffusion fluxes with DGT measurement



# Reasons for higher P uptake in NF solutions

- Direct uptake of colloids

Disk centrifuge data showed presence of small colloids

There is evidence in literature of root uptake of synthetic nanoparticles (20nm)

- Enhancement of P diffusive transport

Colloidal P act as mobile buffer of free ionic P

(DGT data support this)

# Summary

- Colloidal P increased up to 7-fold the uptake flux in Andisols
- Contribution most likely through enhanced diffusion of the free P in presence of labile complexes, although direct uptake cannot be completely excluded
- Higher contribution of colloids for Andisols than for Oxisol likely related to the different nature of colloids: P in humic-Al/Fe-P complexes (P-species abundant in Andisols) probably more labile

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