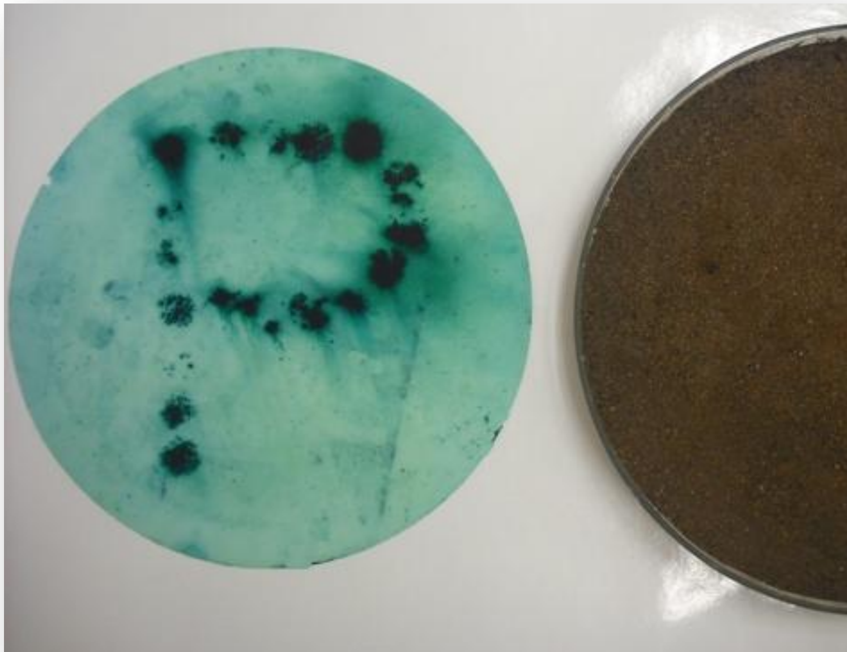
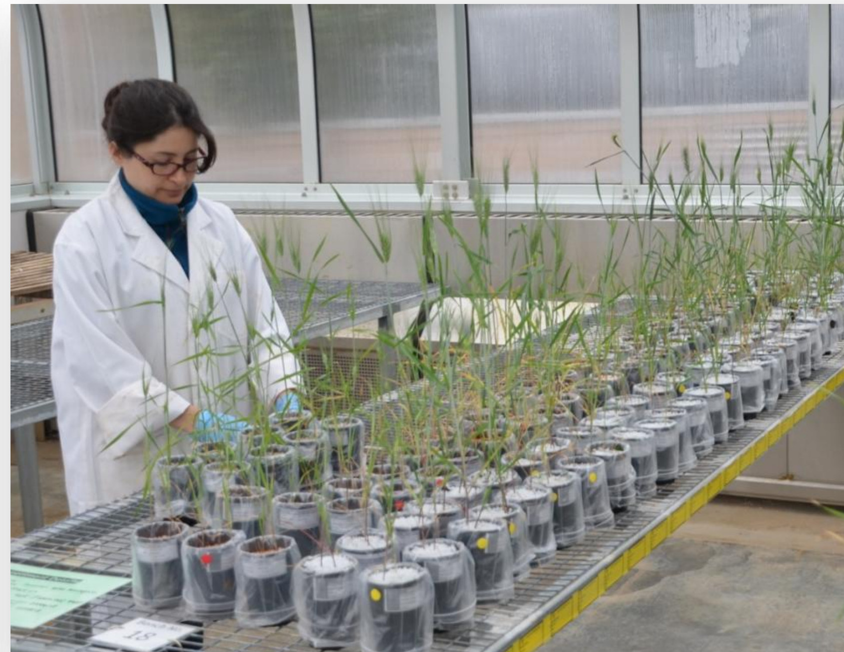




# The response of wheat grown in Andisols and Oxisols to granular and fluid phosphorus fertilizers

Daniela Montalvo , Fien Degryse, and Mike McLaughlin

# Introduction

- Previous studies showed there is more bioavailable P in calcareous soils fertilized with fluid P than with granular P (Holloway et al., 2001; Lombi et al., 2005)
- Increased efficiency of fluid fertilizers was related to less precipitation of Ca-phosphates in and around the fluid P injection zone

Holloway, et al. 2001

# Research question

Can fluid P enhance fertilizer efficiency on acidic strongly P-sorbing soils?

Jaramillo, 2011

Jaramillo, 2011

# Fate of P in acidic soils

Adsorption/precipitation limit P availability

Adsorption reactions:

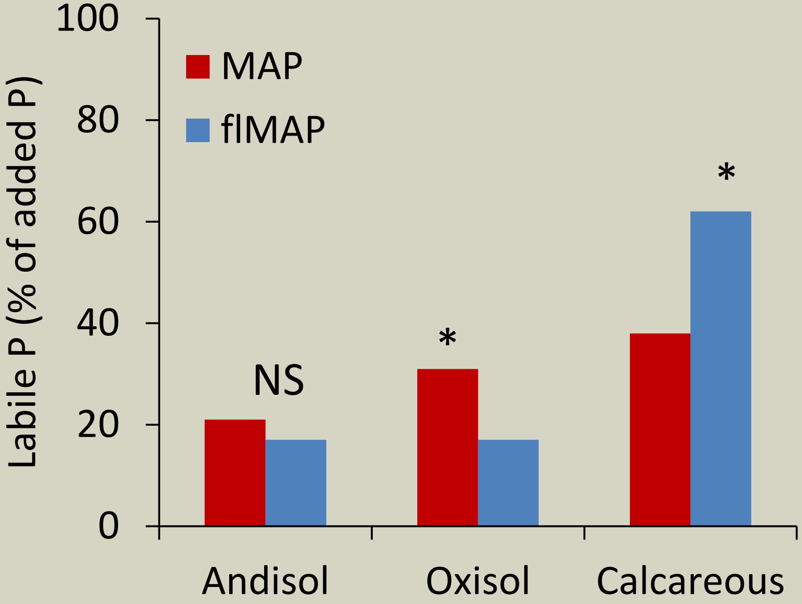
P strongly adsorbed hydrous oxides of Al, Fe

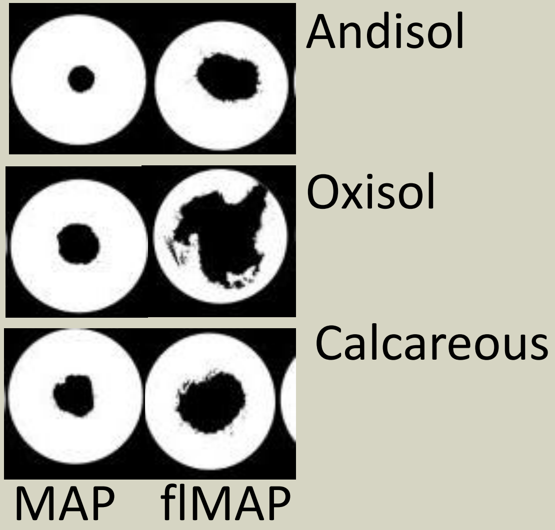
Precipitation reactions:

Few studies have reported Al-and Fe phosphate precipitates in soils

# Behaviour P fertilizers: acidic soils

Montalvo et al. 2014. Soil Sci. Soc. Am. J:78:214-224




- Greater diffusion but not lability from fluid P fertilizers in acidic Al/Fe oxides-rich soils
- Greater diffusion and lability in calcareous soil because of reduced Ca-P precipitation

# Residual MAP composition: acid soils

- ~ 10% of initial P remained in granule
- Al, Fe did not significantly increase in the granule (no movement)
- Ca content increased in residual granule incubated in calcareous soil

| | Elemental comp. (mg granule $^{-1}$) | | | |
|---|---|---|---|---|
| | P | Ca | Al | Fe |
| Unincubated | 9.4a | 0.2b | 0.4a | 0.6ns |
| And. (Chile) | 0.9cd | 0.2b | 0.4a | 0.7 |
| And. (North) | 0.8d | 0.2b | 0.4a | 0.5 |
| Ox. (Green.) | 1.0bc | 0.1c | 0.4a | 0.6 |
| Ox .(Redv.) | 0.9cd | 0.2b | 0.3b | 0.6 |
| Calc. (Pt K.) | 1.2b | 0.7a | 0.4a | 0.6 |

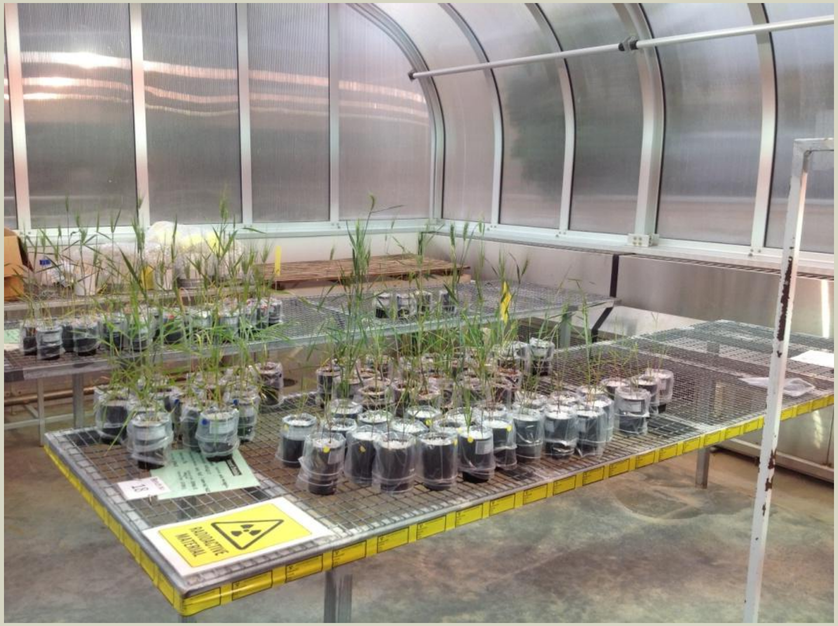
Montalvo et al. 2014. Soil Sci. Soc. Am. J:78:214-224

# Hypothesis

In acidic and Al/Fe oxide-rich soils the application of fluid P will provide no agronomic benefit over granular P sources

# Aim of the study

To evaluate the effectiveness of fluid and granular P fertilizers for wheat grown in acidic strongly P-sorbing soils under glasshouse conditions



# Materials and Methods

- Soils (5):

Andisols (Chile and North, NZ)

Oxisols (Greenwood and Redvale, AUS)

Calcareous Inceptisol (Pt Kenny, AUS)

- Fertilizers (4):

Granular: TSP (0-20-0), MAP (10-22-0), DAP (18-20-0)

Fluid: flMAP (12-26-0)

Control (nil P)

# Selected soil properties

| Soil | pH ($H_2O$) | $Al_{ox}$ | $Fe_{ox}$ | $CaCO_3$ | $C_{DGT}$ | $Ca^{2+}$ |
|---|---|---|---|---|---|---|
| | | ---- g $kg^{-1}$ ---- | | % | µg $L^{-1}$ | $cmol_c$ $kg^{-1}$ |
| Chile | 5.3 | 43 | 17 | b.d.l. | 4 | 1.5 |
| North-NZ | 5.7 | 42 | 8 | b.d.l. | 11 | 6.6 |
| Greenwood | 5.9 | 17 | 4 | b.d.l. | 6 | 4.0 |
| Redvale | 6.4 | 2 | 2 | b.d.l. | 2 | 7.4 |
| Pt Kenny | 8.7 | 0.2 | 0.1 | 28 | 33 | 26.6 |

b.d.l.: below detection limit

$Al_{ox}$, $Fe_{ox}$: oxalate extractable Al and Fe

$C_{DGT}$: Diffusive gradient in thin-film concentration, critical conc. 60 µg $L^{-1}$ (Mason, 2010)

$Ca^{2+}$: $NH_4Cl$ exchangeable Ca

# Materials and Methods

- Basal macro & micro nutrients
- Soils spiked 500 kBq $kg^{-1}$ $^{33}P$
- Fertilizer rate: 150 mg $kg^{-1}$ (And. & Ox.)

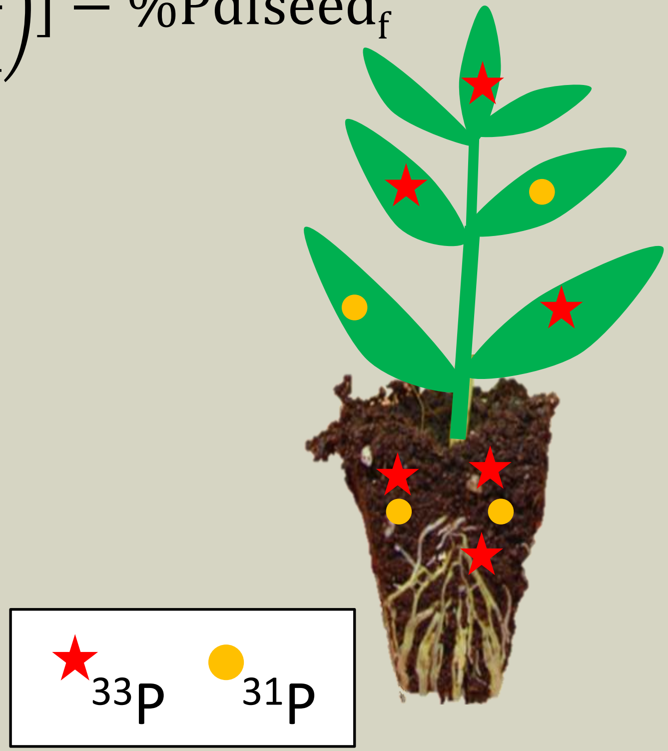
  40 mg $kg^{-1}$ (Calcareous Incep.)
- Wheat plants harvested after 6 weeks
- Shoots digested and analysed for total P and $^{33}P$ activity

# Materials and Methods

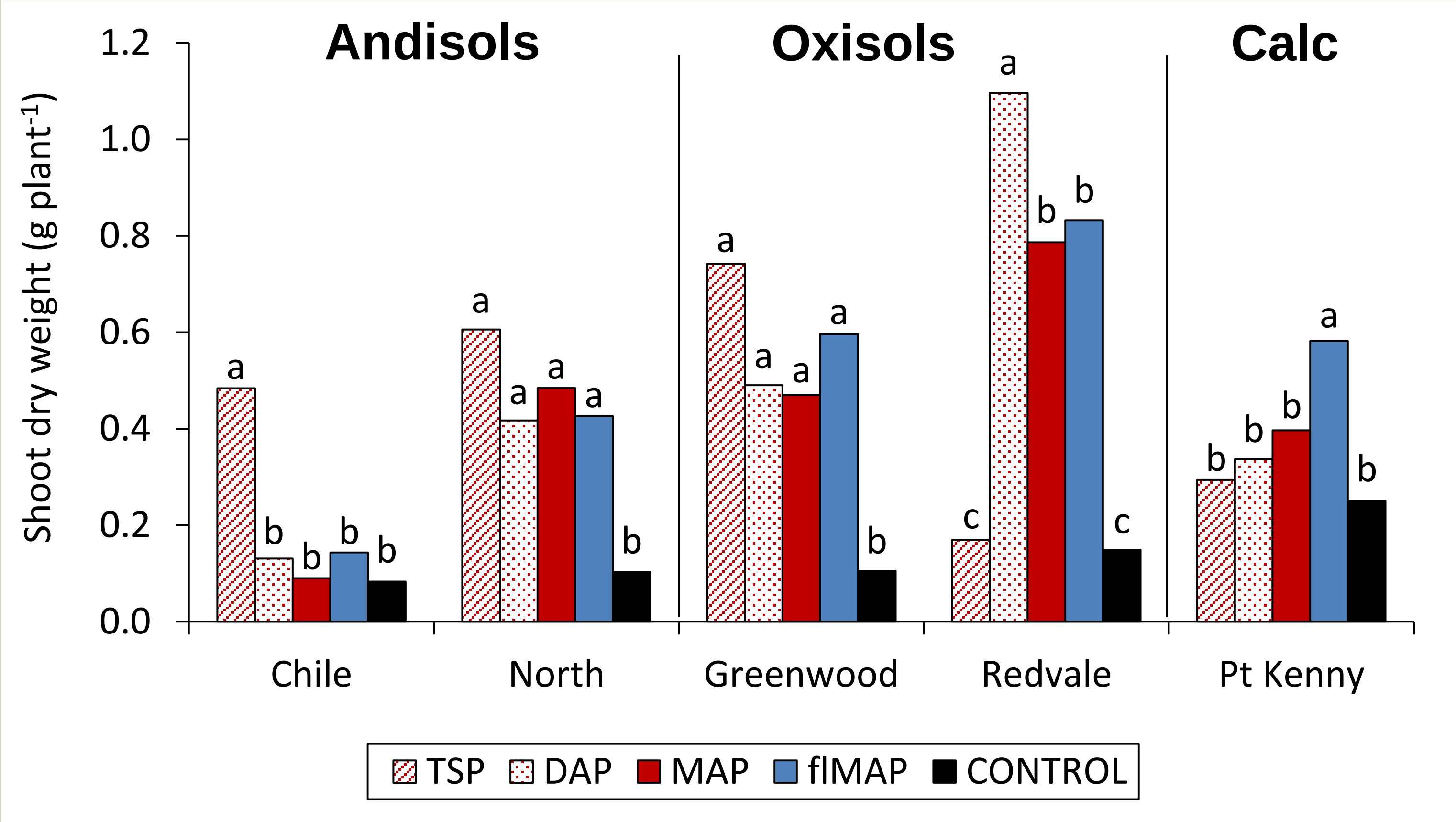
Isotopic dilution (indirect labeling) to determine % P in the plant that derived from fertilizer

$$\%\mathrm{Pdff} = 100 \times [1 - \left(\frac{{}^{33}\mathrm{P}_{\mathrm{shoot}_f}}{\mathrm{SA}_{\mathrm{Pdfsoil}} \times {}^{31}\mathrm{P}_{\mathrm{shoot}_f}}\right)] - \%\mathrm{Pdfseed}_f$$

$$\mathrm{SA}_{\mathrm{Pdfsoil}} = \frac{{}^{33}\mathrm{P}_{\mathrm{shoot}_{ctrl}}}{{}^{31}\mathrm{P}_{\mathrm{shoot}_{ctrl}} - \mathrm{Pdfseed}_{ctrl}}$$

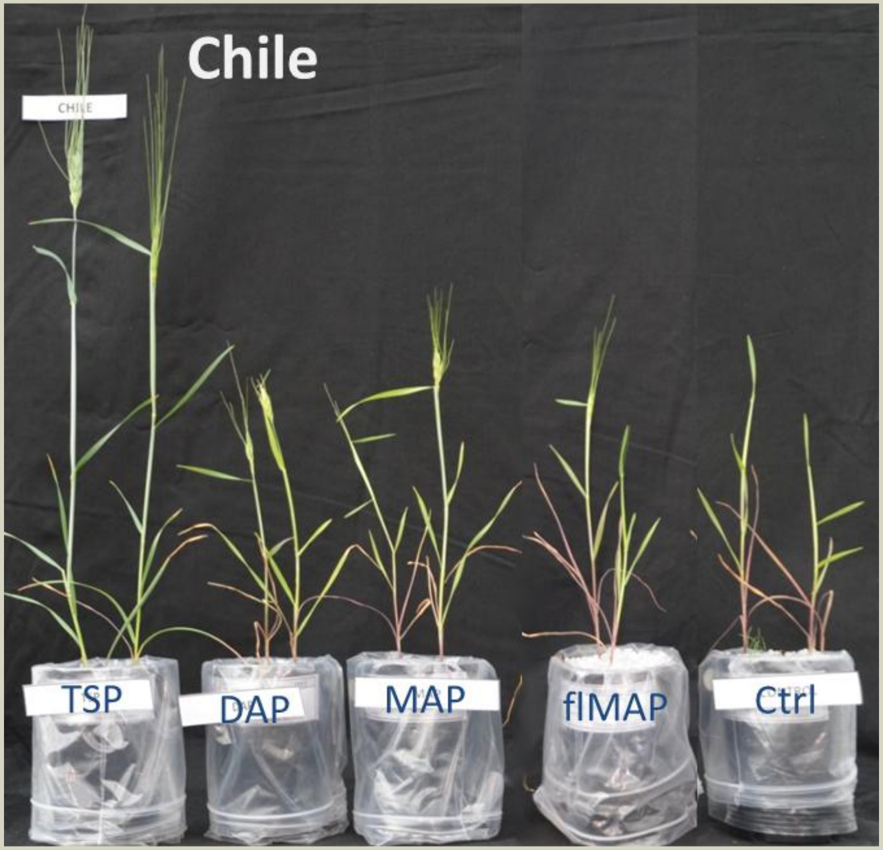


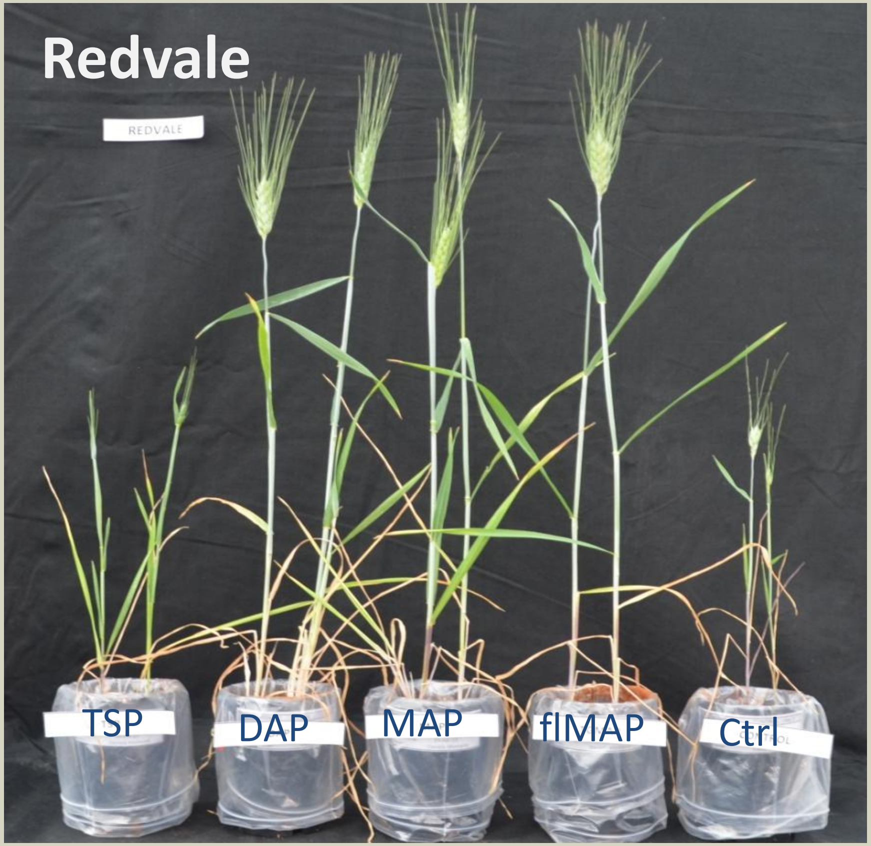
# Plant response: shoot dry weight




- And. & Ox.: N.S. between flMAP and MAP
- Calc.: flMAP produced 31% more dry matter than MAP

# Plant response to fertilizers

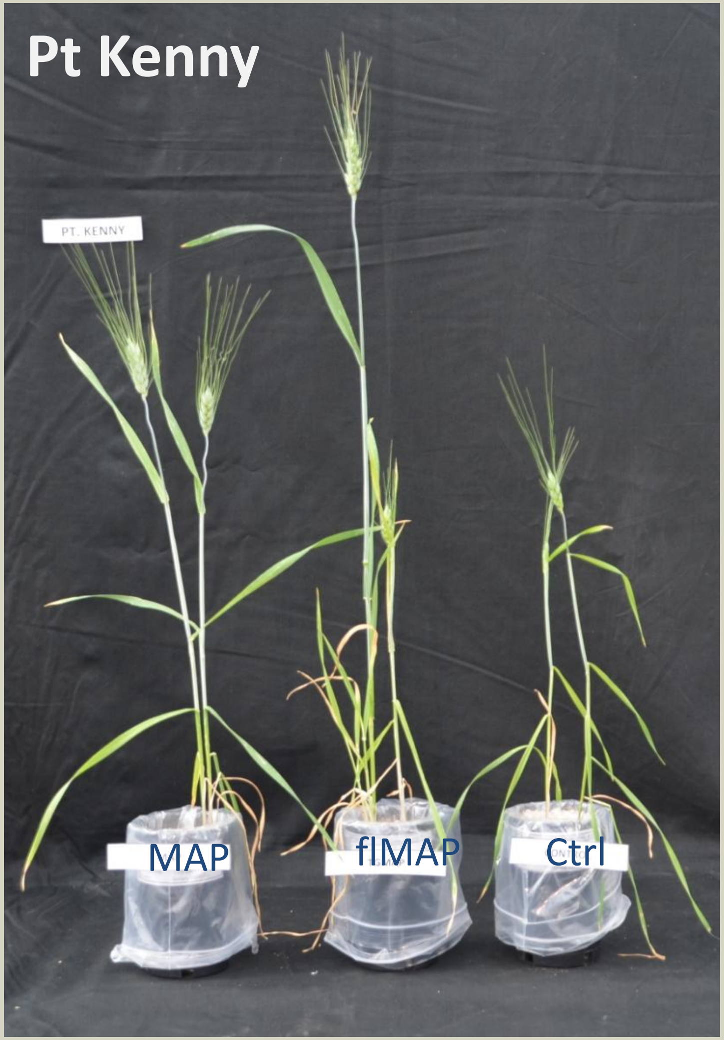


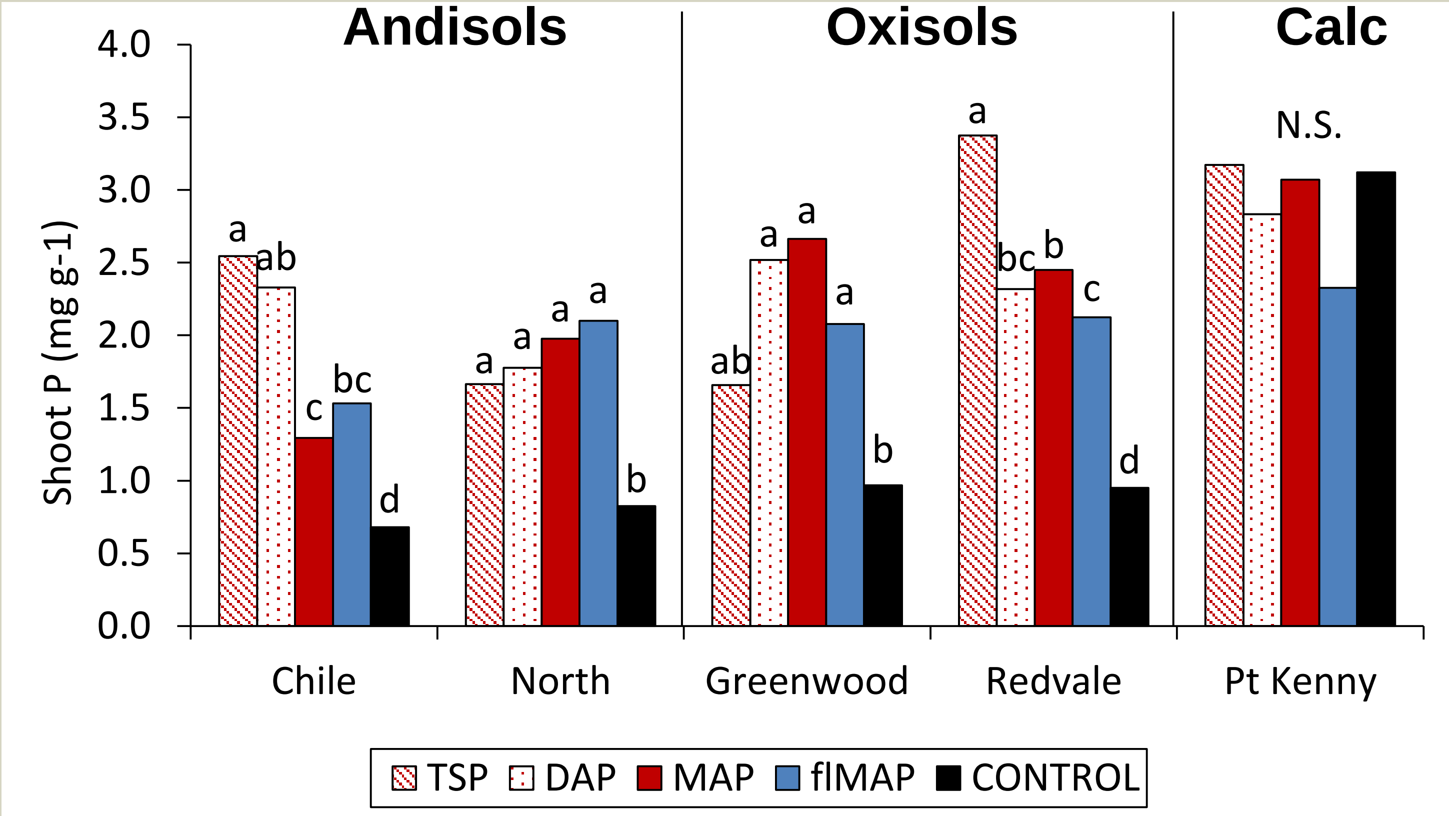

TSP: Ca nutrition effect

TSP: poor performance likely Ca-P precipitation

# Plant response to fertilizers

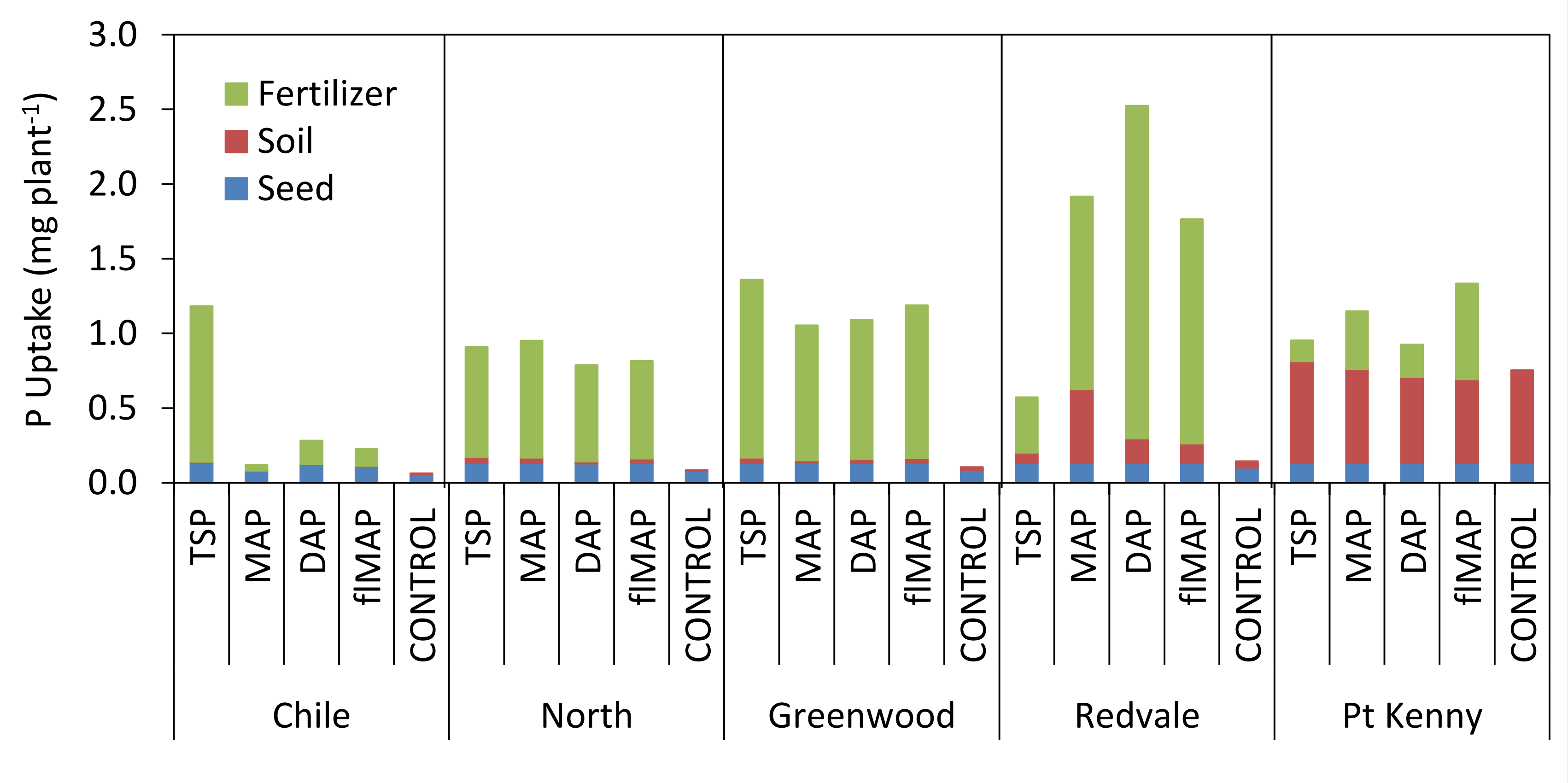


# Plant response: shoot P




- Plant response to fertilizer application

# Plant P uptake: Andisols & Oxisols




- And. & Ox.: Soil P contribution to the shoots is minimal
- Calc.: Soil P contribution to the shoots ~58% average

# P derived from fertilizer (%)

| Fertilizer | Chile | North | Greenwood | Redvale | Pt Kenny |
|---|---|---|---|---|---|
| **TSP** | 88a | 80NS | 81NS | 65b | 12c |
| **MAP** | 23c | 79 | 85 | 79a | 30b |
| **DAP** | 54b | 73 | 84 | 88a | 20c |
| **flMAP** | 41bc | 78 | 86 | 85a | 49a |

- And. & Ox.: flMAP = MAP
- Calc.: flMAP > MAP

# Summary

- No agronomic benefits in Andisols and Oxisols from the application of fluid P fertilizers
- Calcium phosphate sources (e.g. TSP) should be avoided in soils with near neutral to basic pH to avoid opportunities for Ca-P precipitation
- In Andisols and Oxisols most of crop P derived from fertilizer P, which highlights the importance of fertilizer application

# Acknowledgments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