

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:

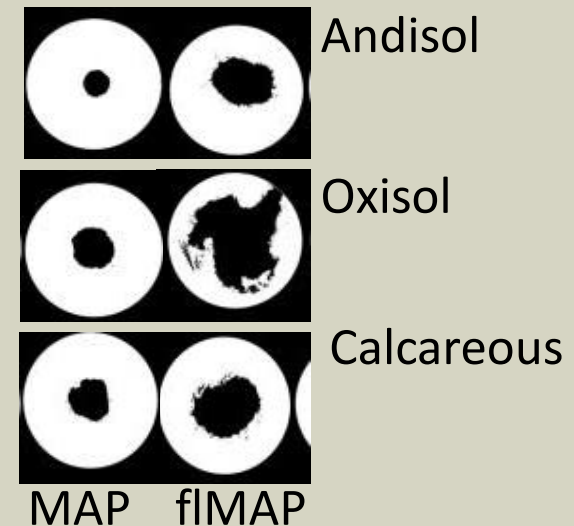
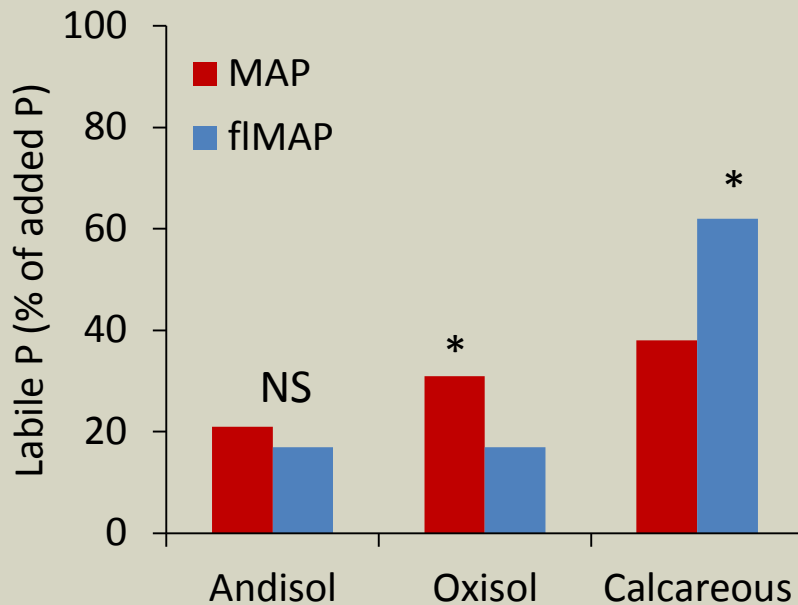
P strongly adsorbed hydrous oxides of Al, Fe

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 ₂ O)	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)

Ca²⁺: NH₄Cl exchangeable Ca

→ Materials and Methods

- Basal macro & micro nutrients
- Soils spiked 500 kBq kg⁻¹ ³³P
- 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 ³³P activity

→ Materials and Methods

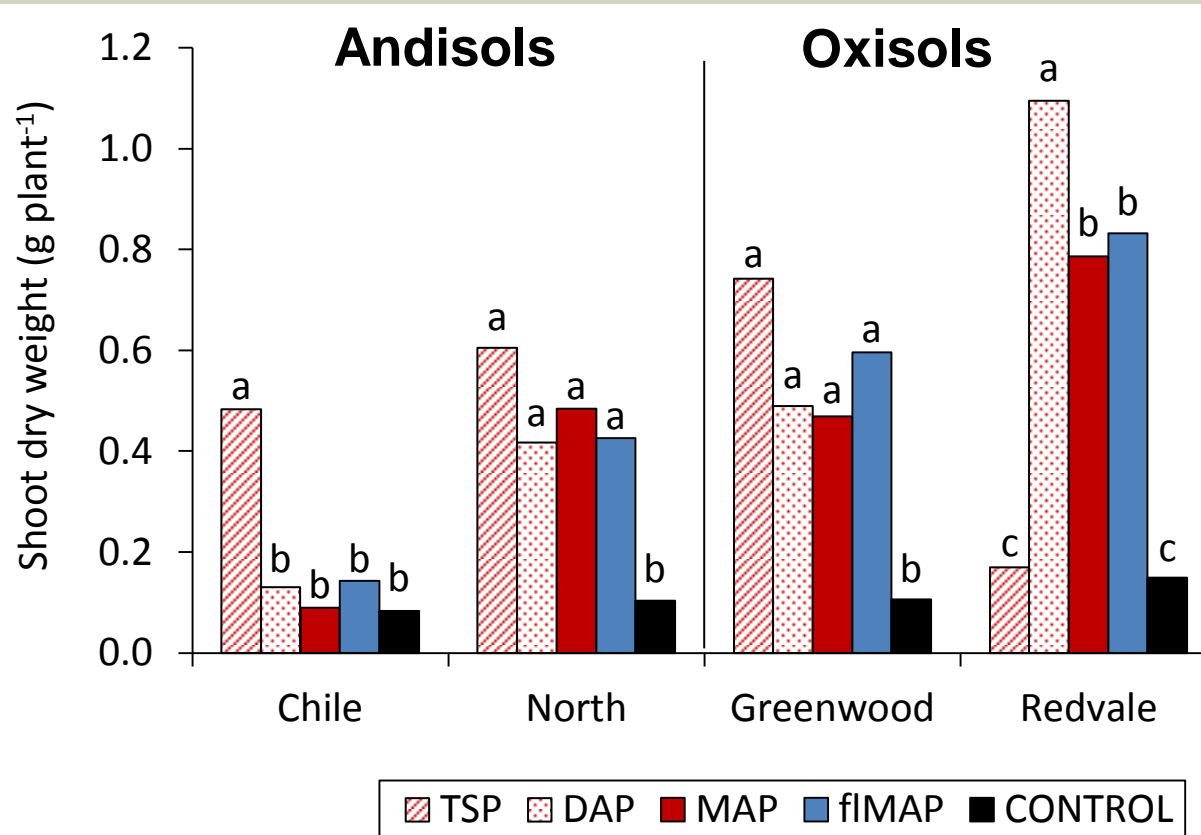
Isotopic dilution (indirect labeling) to determine % P in the plant that derived from fertilizer

$$\%P_{dff} = 100 \times \left[1 - \left(\frac{{}^{33}\text{P}_{\text{shoot}_f}}{\text{SA}_{\text{Pdfsoil}} \times {}^{31}\text{P}_{\text{shoot}_f}} \right) \right] - \%P_{\text{dfseed}_f}$$

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

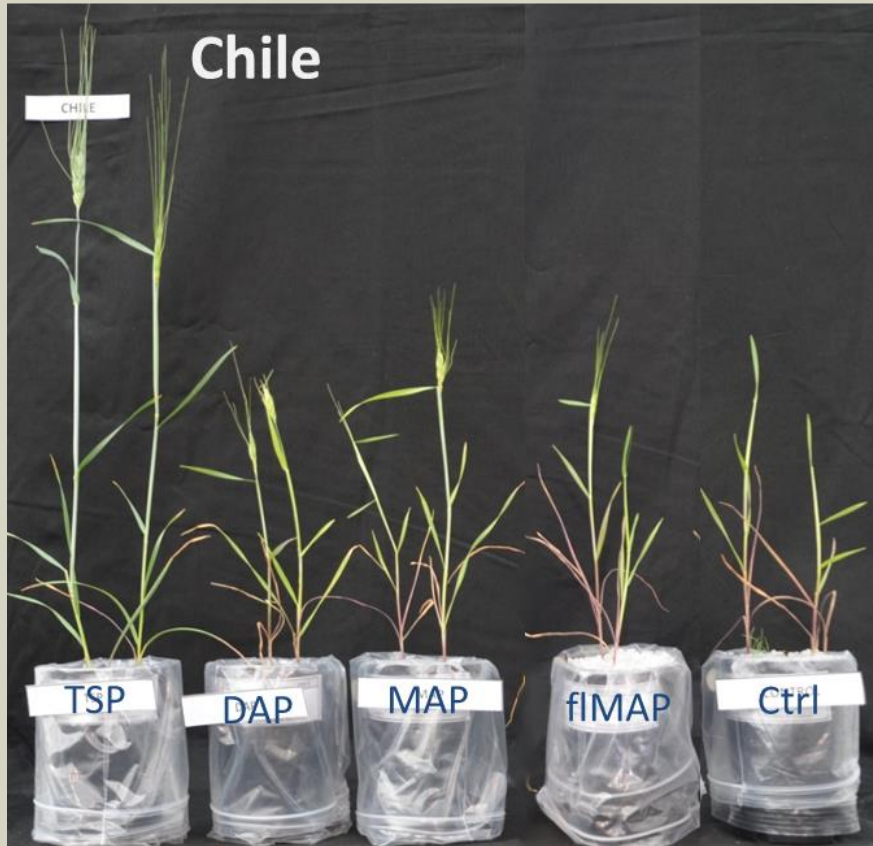


→ Plant response: shoot dry weight

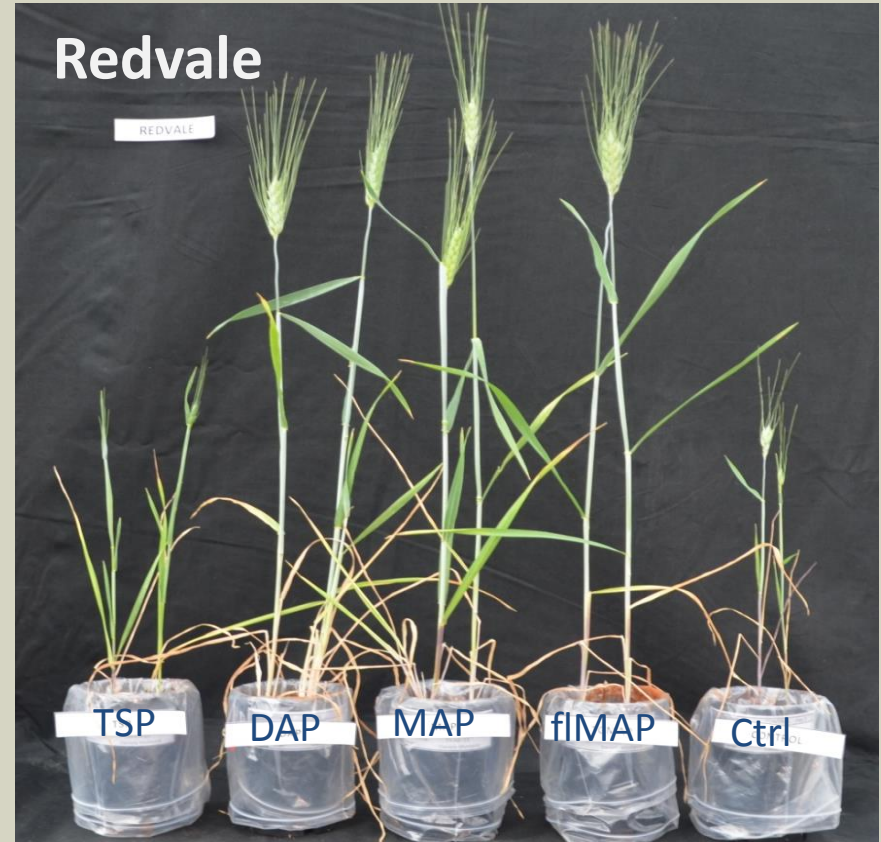


- And. & Ox.: N.S. between flMAP and MAP
- Calc.: flMAP produced 31% more dry matter than MAP

→ Plant response to fertilizers



TSP: Ca nutrition effect



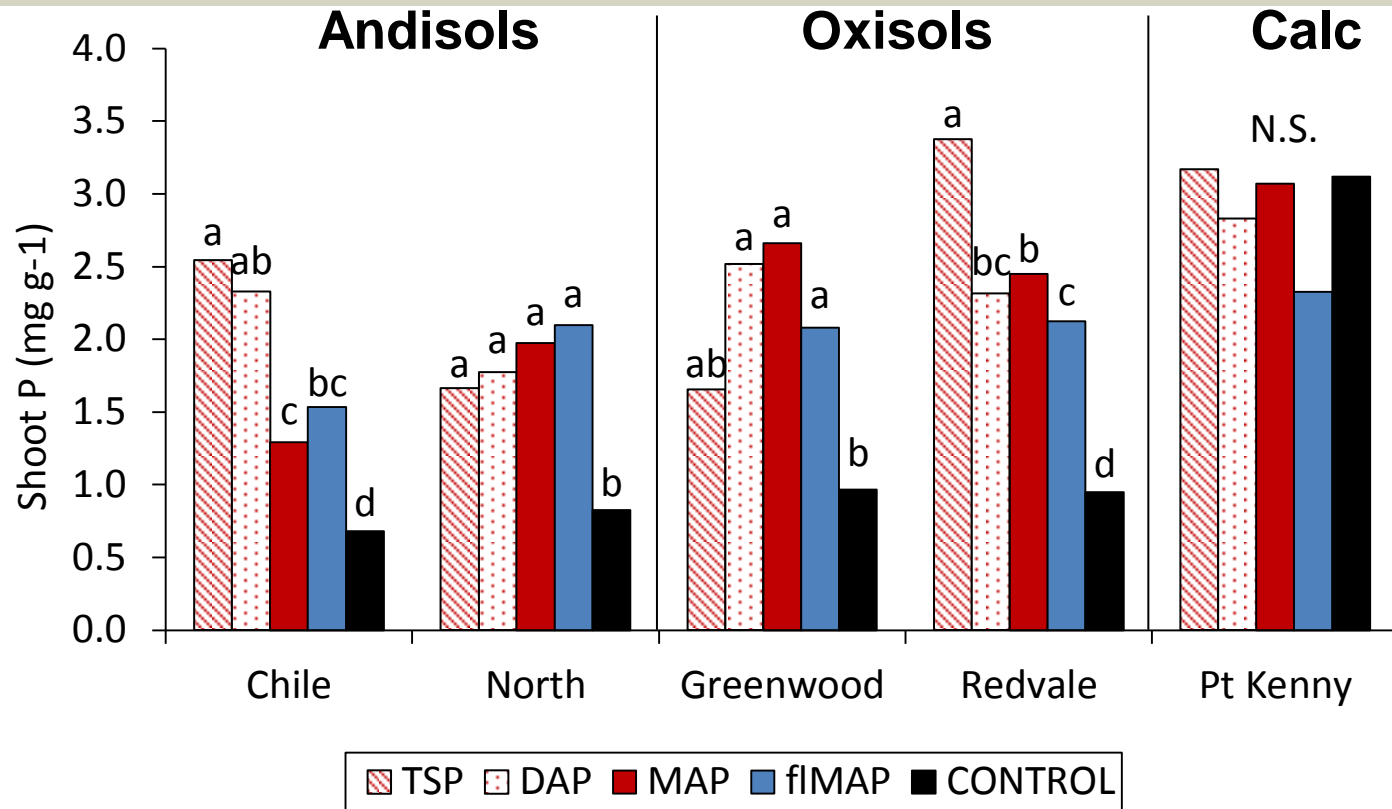
TSP: poor performance
likely Ca-P precipitation

→ Plant response to fertilizers





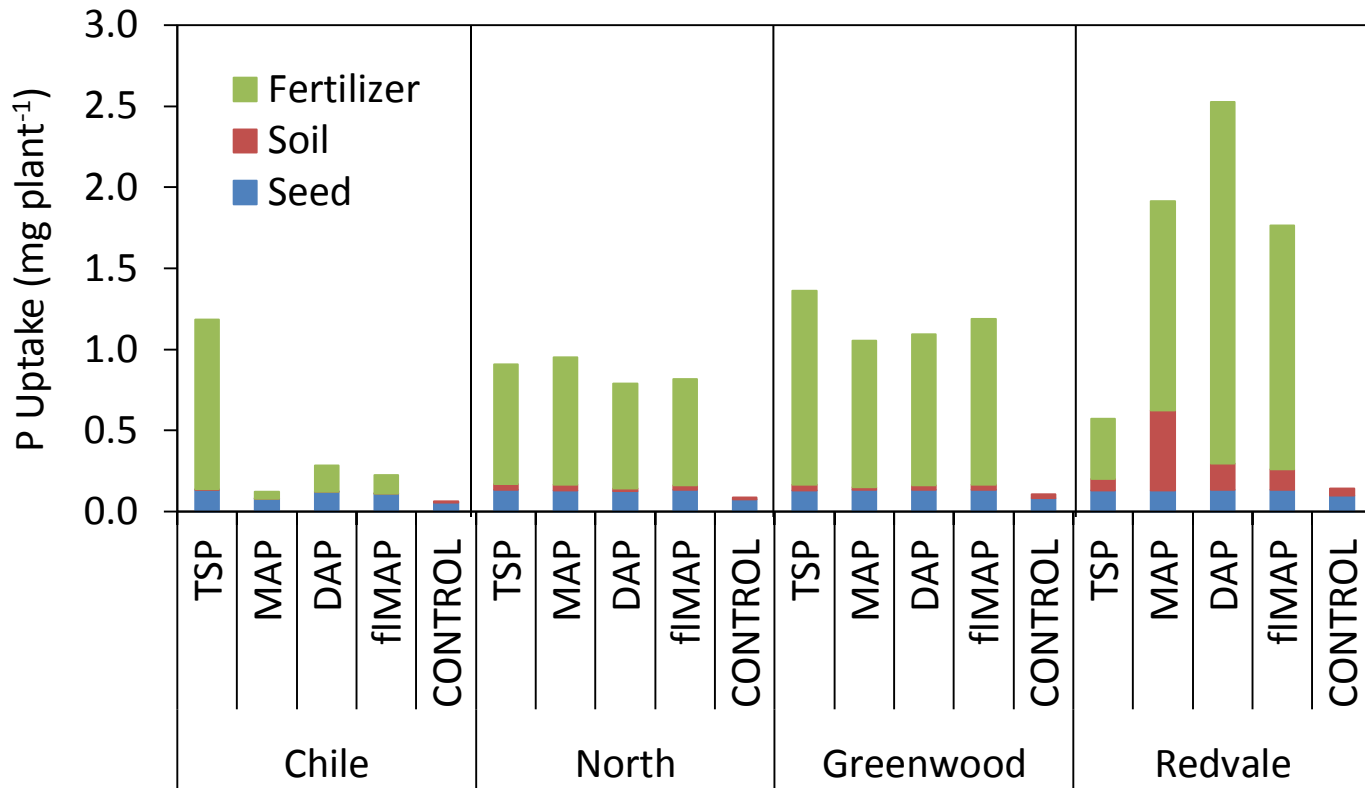
Plant response: shoot P



- 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

- Collection of soil in Australia, New Zealand, and Chile- Drs Mike Bell, Leo Condrón, and Carlos Michiels
- Technical staff- Bogumila Tomczak, Colin Rivers, and Ashleigh Broadbent
- Funding



THE UNIVERSITY
of ADELAIDE

GRDC

Grains
Research &
Development
Corporation

