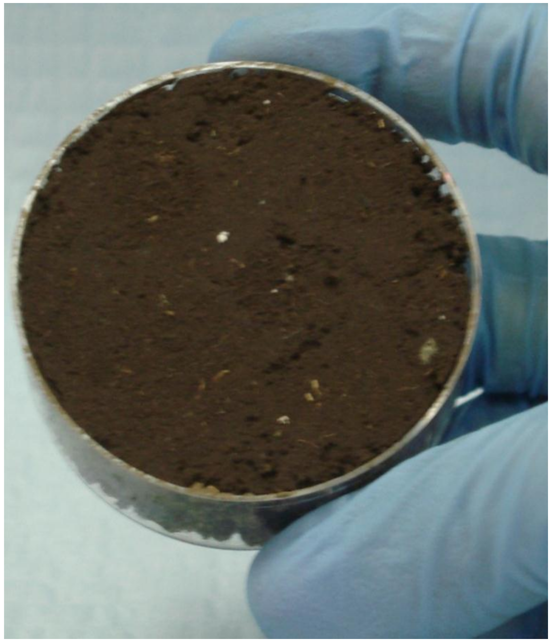


Phosphorus chemistry around placement of granular and fluid fertilizers in acidic strong P-sorbing soils

Daniela Montalvo , Fien Degryse, and Mike McLaughlin

Introduction

- Previous studies demonstrated greater efficiency of fluid P fertilizers in calcareous soils (Holloway et al., 2001; Lombi et al., 2004)
- Increased efficiency of fluid fertilizers over granular P formulations was found to be related to less precipitation of Ca-phosphates in and around the fluid P injection zone

Fluid fertilizer P in calcareous soils

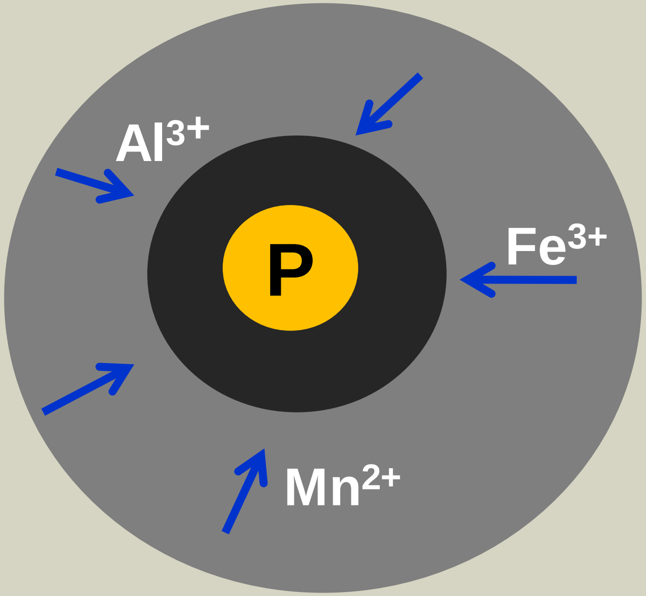
Granular MAP **Liquid MAP**

Holloway R.E., Bertrand I., Frischke A.J., Brace D.M., McLaughlin M.J., Sheppard W. (2001) Improving fertiliser efficiency on calcareous and alkaline soils with fluid sources of P, N and Zn. Plant and Soil 236:209-219.

Introduction

- In acidic soils with high content of P-sorbing minerals (e.g. Al/Fe oxyhydroxides) the efficiency of P fertilizers is often limited
- In these soils strong adsorption reactions are known to limit P availability, as well as precipitation of Al- and Fe-phosphates in and around the fertilizer granule (Lindsay et al., 1962)

Behaviour granular fertilizers: acid soils

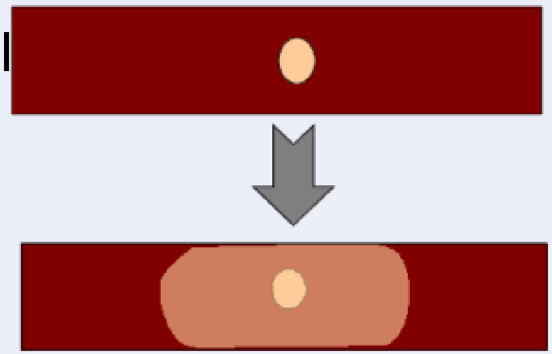


- Al, Fe, and *X* can form <u>precipitates</u> with phosphate from the fertilizer (*X*: e.g. Mn^{2+})
- Limit diffusion of P and reduce efficiency of fertilizer

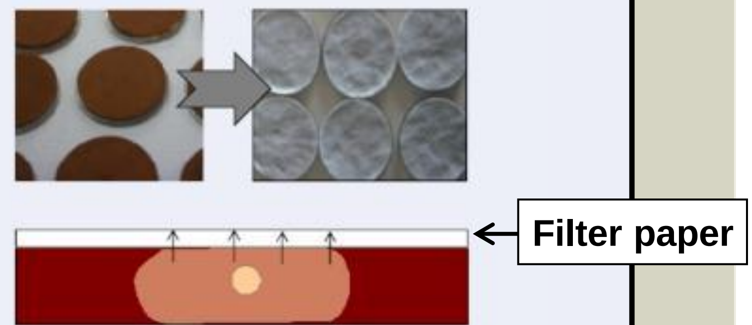
<u>Hypothesis:</u> If fertilizer P availability is limited by precipitation reactions (e.g. Al/Fe-P forms), then fluid fertilizers may be beneficial

Previous work: Visualization of P diffusion

Petri dish packed with soil

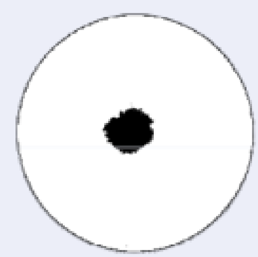


(i) Incubation of soil with fertiliser granule



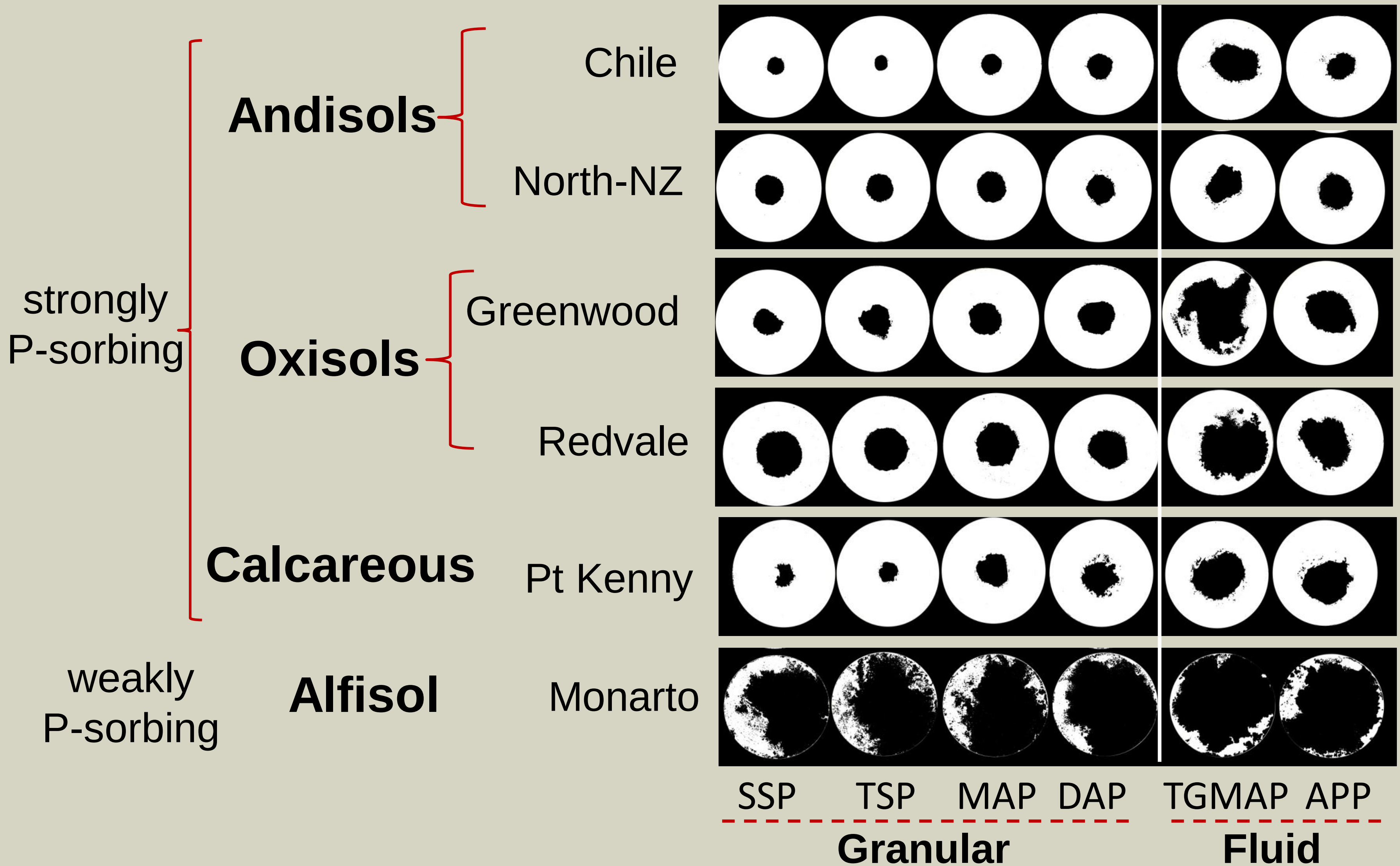
(ii) Filter paper impregnated with sink for nutrient then placed on soil surface

(iii) Development: using a reagent that colours with the nutrient



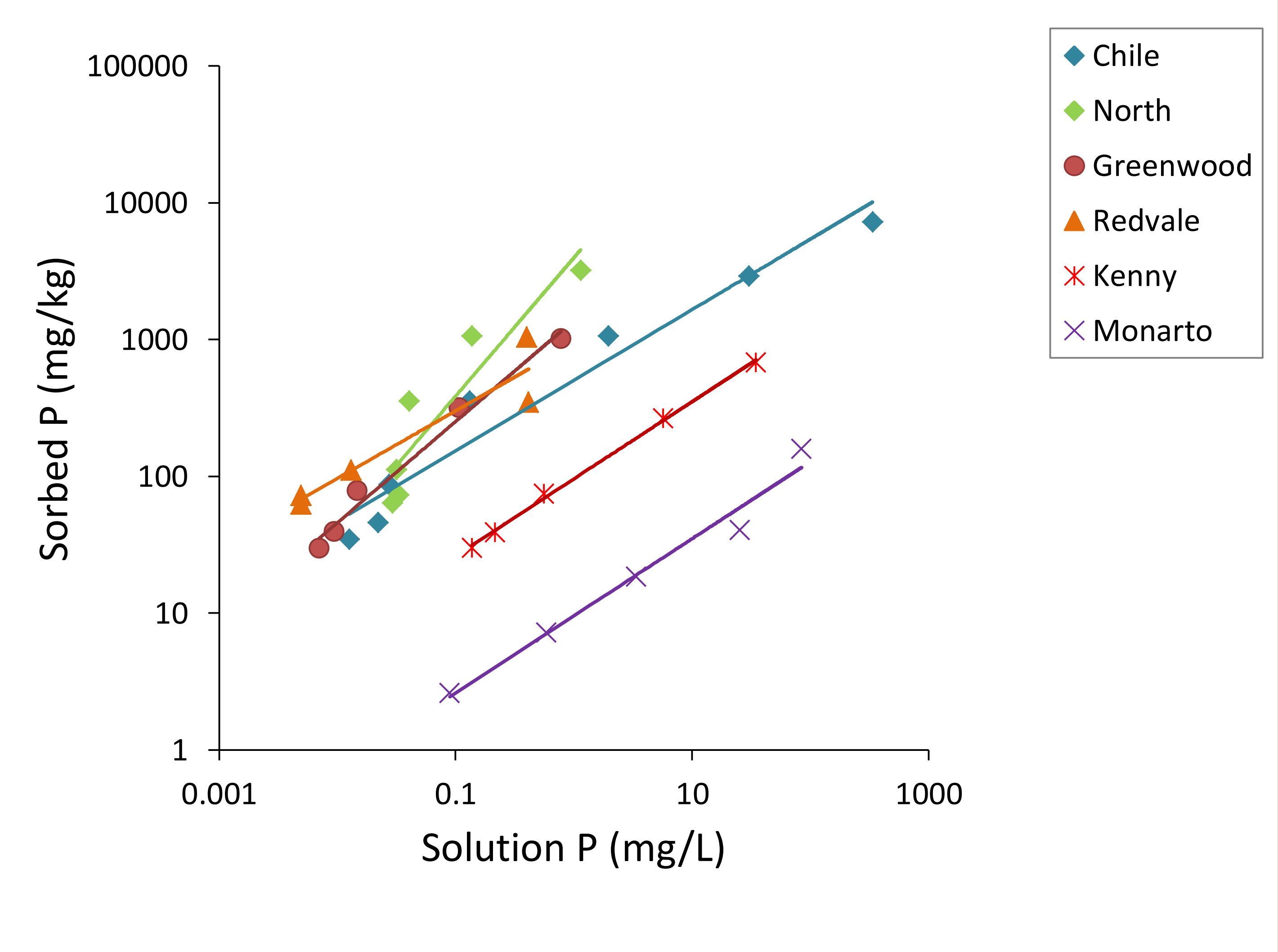
(iv) Image analysis using imaging software

Previous work: Visualization of P diffusion



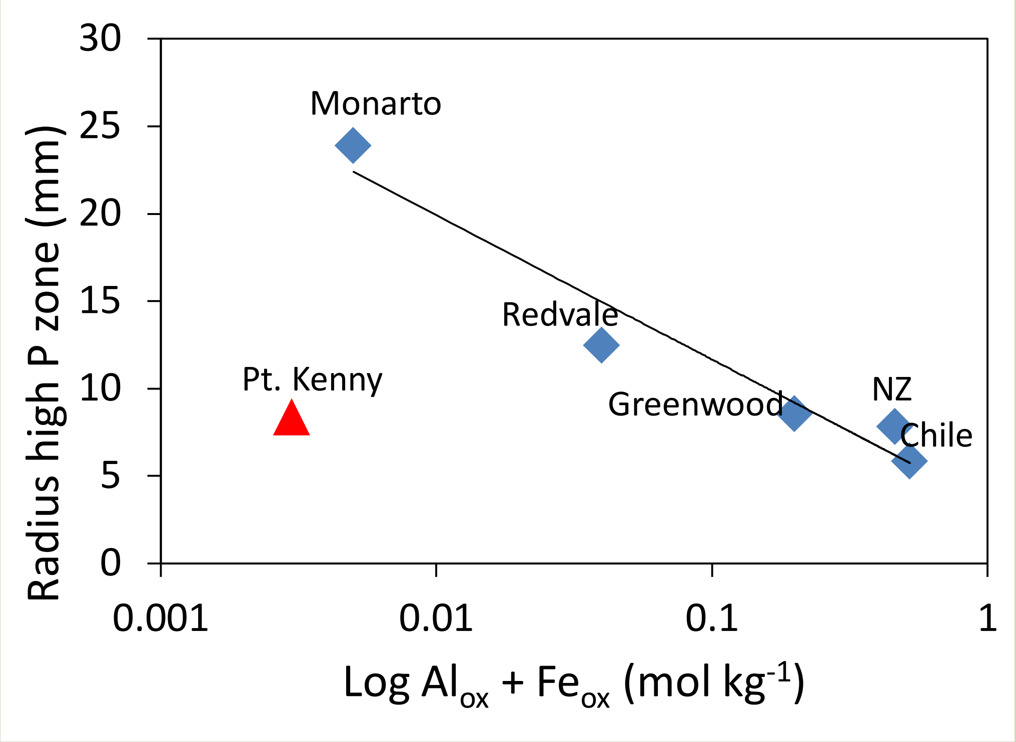
Greater diffusion of P for fluids than for granulars (except for Monarto)

Previous work: P sorption isotherms



Diffusion radius of P as function of ox. Al+Fe

- In non-calcareous soils amorphous Al and Fe hydroxides control P diffusion
- In the calcareous soil Ca-P precipitation most likely limit P diffusion



Summary previous work

- In all P-sorbing soils (acidic and calcareous) greater diffusion of P from fluid than granular fertilizers

BUT....

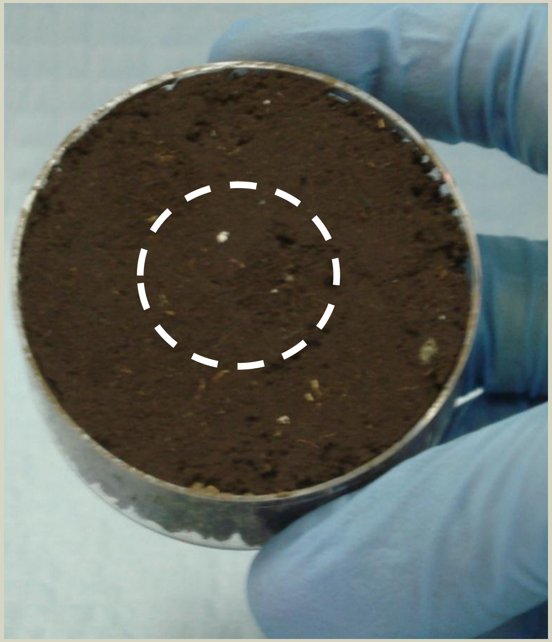
- Does greater diffusion imply greater availability (less precipitation or irreversible sorption)?

Objectives

- Investigate the diffusion and potential availability of P from granular and fluid fertilizers applied in acidic strongly P-sorbing soils

Experimental design: soil incubation for 35 d

- Soils:2 Andisol, 2 Oxisol, 1 Calcic Inceptisol, 1 Alfisol
- Fertilizers @ 9.2 mg/Petri dish
  - Granular: SSP (0-8.8-0), TSP (0-20-0), MAP (10-22-0), DAP (18-20-0)
  - Fluid: TGMAP (12-26-0) applied at 200 µL vol., APP (11-16-0) applied at 58 μL vol.
- Sampling: 0-7.5 mm (inner) and 7.5-27.5 mm (outer)
- Analyzed for: pH, total P, water soluble P, labile P (E-value)



Experimental design: soil incubation for 35 d

- At the end of incubation period residual granules were removed and analyzed for total P, Ca, Al, and Fe (from additional incubated Petri dishes)

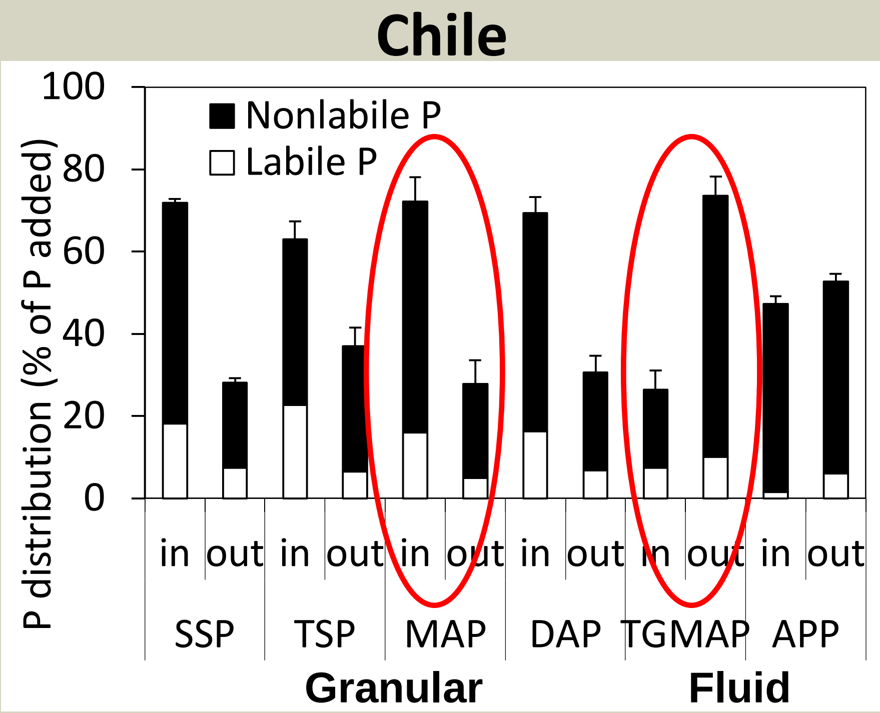
Selected soil properties

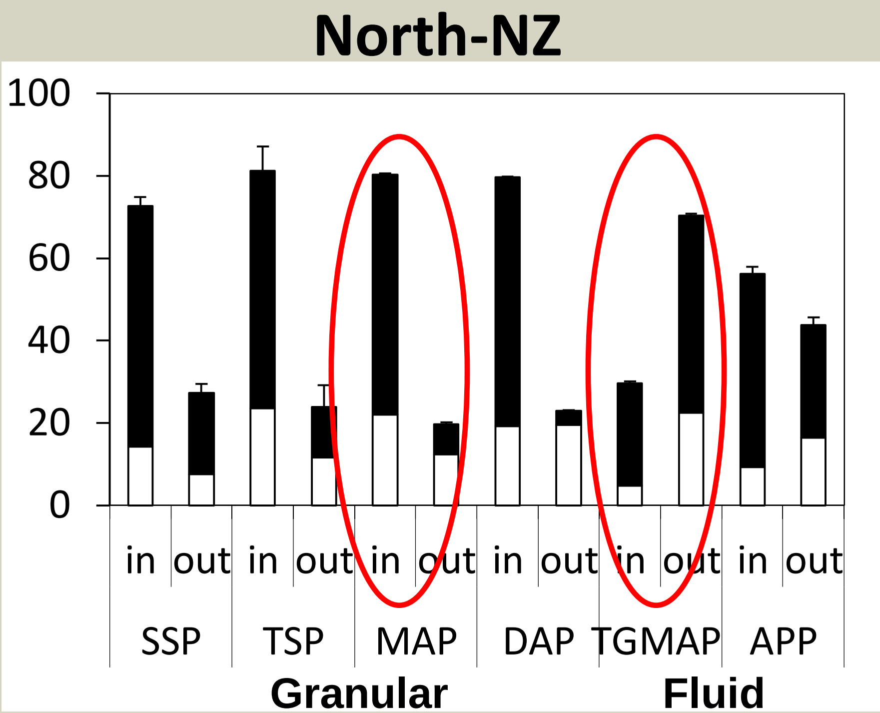
Soil	Order	pH (H_2O)	Al_{ox}	Fe_{ox}	$CaCO_3$	Clay
			----g kg^{-1}----		-----%-----	
Chile	Andisol	5.3	43	17	b.d.l.	14
North-NZ	Andisol	5.7	42	8	b.d.l.	7
Greenwood	Oxisol	5.9	17	4	b.d.l.	13
Redvale	Oxisol	6.4	2	2	b.d.l.	61
Pt Kenny	Calcic Inceptisol	8.7	0.2	0.1	28	3
Monarto	Alfisol	7.1	0.3	0.3	b.d.l.	8

b.d.l.: below detection limit

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

Source effect on diffusion : Andisols

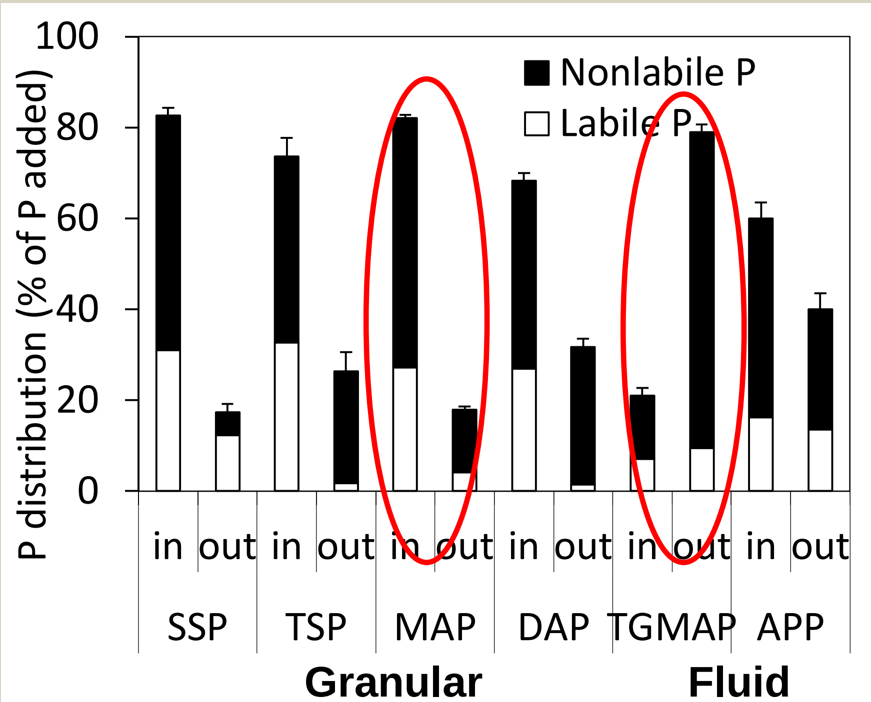




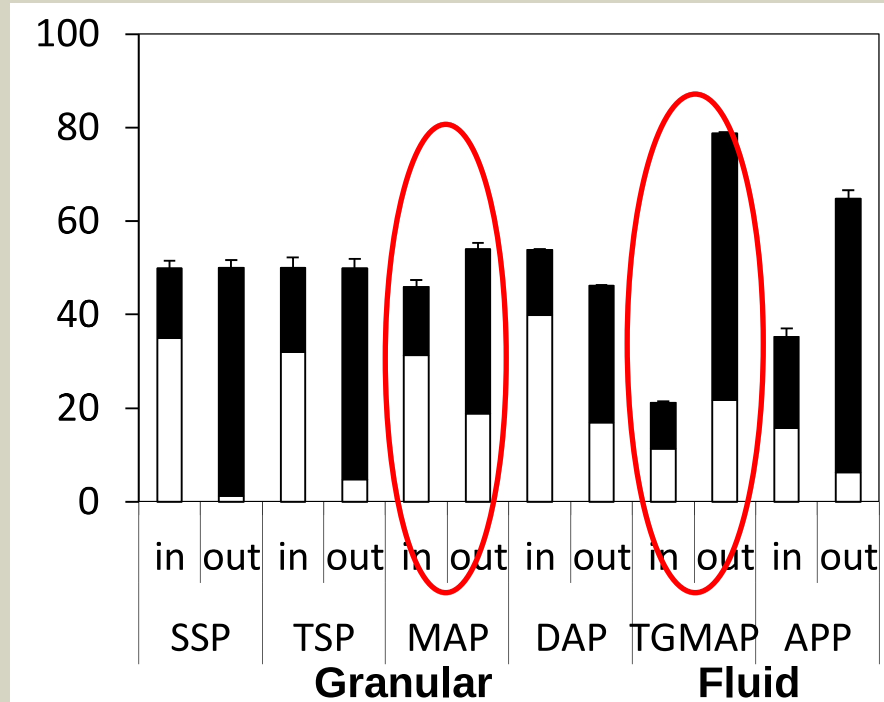
- Greater diffusion of P to outer soil section with flMAP (agreement with visualization)

Source effect on diffusion : Oxisols

Greenwood



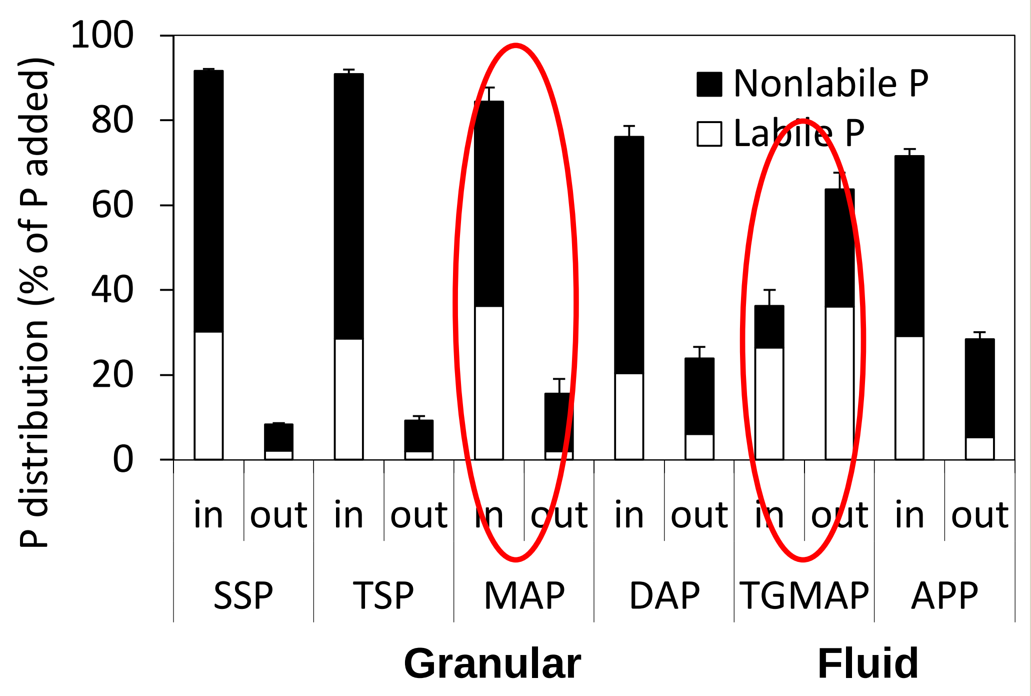
Redvale



➢ Greater diffusion of P to outer soil section with flMAP (agreement with visualization)

Source effect on diffusion : Calcareous

Pt Kenny



➢Greater diffusion of P to outer soil section with flMAP (agreement with visualization)

Source effect on lability: Andisols

Chile

Labile P (% of added)					
SSP	TSP	MAP	DAP	TGMAP	APP
26[ab]	29[a]	21[ab]	23[ab]	17[bc]	8[c]

North-NZ

Labile P (% of added)					
SSP	TSP	MAP	DAP	TGMAP	APP
22[c]	36[ab]	34[ab]	39[a]	27[bc]	26[c]

Granular MAP ≈ Fluid MAP

Source effect on lability: Oxisols

Greenwood

Labile P (% of added)					
SSP	TSP	MAP	DAP	TGMAP	APP
43[a]	34[ab]	31[ab]	28[bc]	17[c]	30[bc]

Redvale

Labile P (% of added)					
SSP	TSP	MAP	DAP	TGMAP	APP
36[b]	37[b]	50[a]	57[a]	33[b]	22[c]

Granular MAP > Fluid MAP

Source effect on lability: calcareous

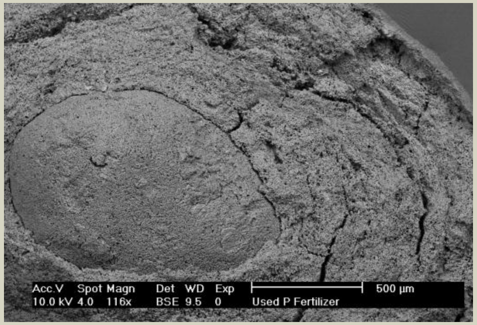
Pt Kenny

Labile P (% of added)					
SSP	TSP	MAP	DAP	TGMAP	APP
32[b]	31[b]	38[b]	26[b]	62[a]	35[b]

Granular MAP < Fluid MAP

Residual MAP granule composition

- ~ 10% of initial P remained in granule
- Ca content increased in residual granule incubated in Pt Kenny soil
- Al, Fe did not significantly increase



	Elemental composition (mg)			
	P	Ca	Al	Fe
Unincubated	9.4a	0.2b	0.4a	0.6ns
Chile	0.9cd	0.2b	0.4a	0.7
North	0.8d	0.2b	0.4a	0.5
Greenwood	1.0bc	0.1c	0.4a	0.6
Redvale	0.9cd	0.2b	0.3b	0.6
Pt Kenny	1.2b	0.7a	0.4a	0.6
Monarto	1.0bc	0.4b	0.4a	0.7

Summary

- Irrespective of fertilizer ~ 10% of initial P remained in residual granule, likely P associated with impurities from phosphate rock (Al, Fe, Ca, Mg)
- Greater diffusion and lability of P from fluid P fertilizers in calcareous soils (in agreement with previous work from our laboratory)
- *Greater diffusion but not lability* from fluid P fertilizers in soils rich in Al/Fe oxides (Andisols, Oxisols)
- In non-calcareous soils P availability in the fertilizer reaction zone limited by strong adsorption rather than precipitation reactions

Summary

- When strong adsorption reactions reduce P availability, fluid fertilizers unlikely to provide additional benefit over granular sources

- Recommended management practice: banding placement of fertilizer to minimize opportunities for strong P sorption

- Future work: a pot trial will assess the hypothesis that fluid fertilizers provide no agronomic benefits in acidic, Al/Fe oxide-rich soils

Acknowledgments

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