

The fate of fertiliser phosphorus in pastures

A field study using isotopic tracers to label single superphosphate granules

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Phosphorus in pasture systems

- Managed grazing systems are the most geographically extensive land use worldwide, occupying ~ 25 % of the world's land surface.
- Phosphorus (P) is often limiting in pastures and P fertiliser is essential for improved productivity.
- Fertiliser P use efficiency of pastures is considered low and is thought to be as a result of soil 'fixation' processes.

Scenario 1



Scenario 2



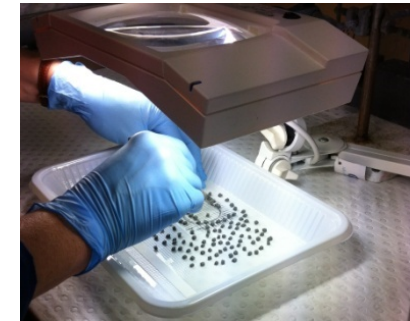
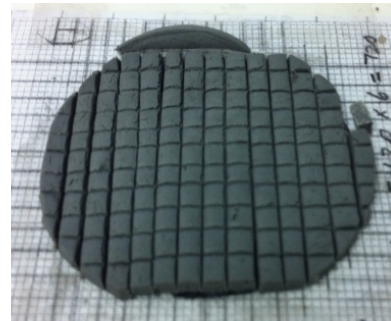
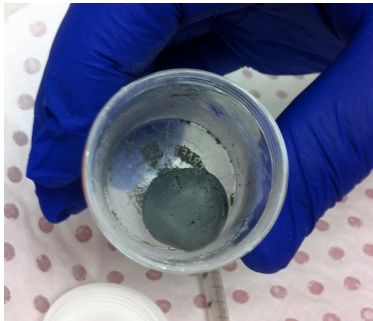
Experimental design 1

- The aim of this study was to measure the fate of fertiliser P in clover pastures using ^{33}P labelled single superphosphate (SSP).
- Two field sites under permanent pasture ($> 450 \text{ mm rainfall yr}^{-1}$)
 - Ginninderra, near Canberra (Australian Capital Territory).
 - Kybybolite, near Naracoorte (South Australia).
- Subterranean clover pasture (5 m \times 5 m area)
- PVC cores (15 cm $\varnothing \times$ 15 cm high) inserted to make in-tact cores.
- Treatments included:
 - Control (no fertiliser)
 - Surface applied commercial SSP ($\sim 10 \text{ kg P ha}^{-1}$)
 - Surface applied ^{33}P labelled SSP granules ($\sim 10 \text{ kg P ha}^{-1}$)



Experimental design 2

- SSP was labelled with a ^{33}P radionuclide using a “press and cut” technique.

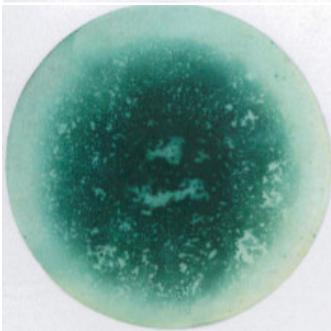


- Regular biomass cuts were taken (2 at Ginninderra and 4 at Naracoorte).
- At the final cut, the remaining SSP granules were collected and the core soil separated into two layers (0 – 4 cm and 4 – 8 cm).
- NaHCO_3 , NaOH-EDTA , and ignition- H_2SO_4 extractions of soil with P concentration (P-31) and radioactivity (P-33) measured in the total and inorganic fractions; organic P by difference.

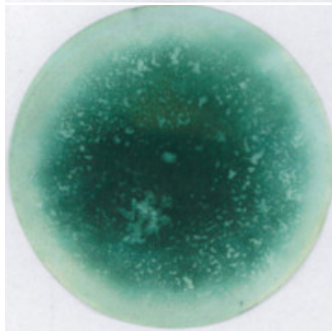
Validation of ^{33}P labelled SSP granules

Commercial SSP granules

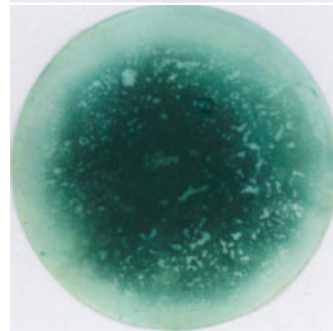
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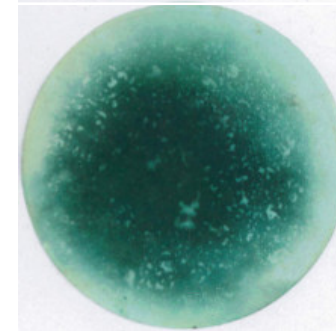
Replicate 2



Replicate 3

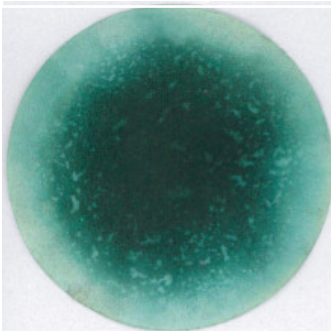


Replicate 4



^{33}P labelled SSP granules

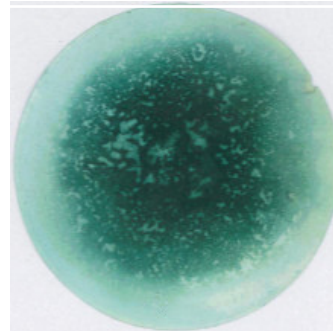
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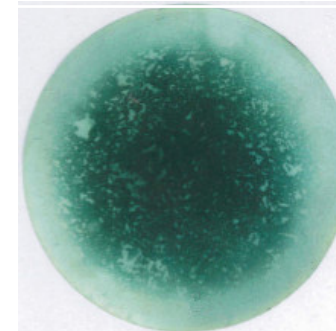
Replicate 2



Replicate 3



Replicate 4



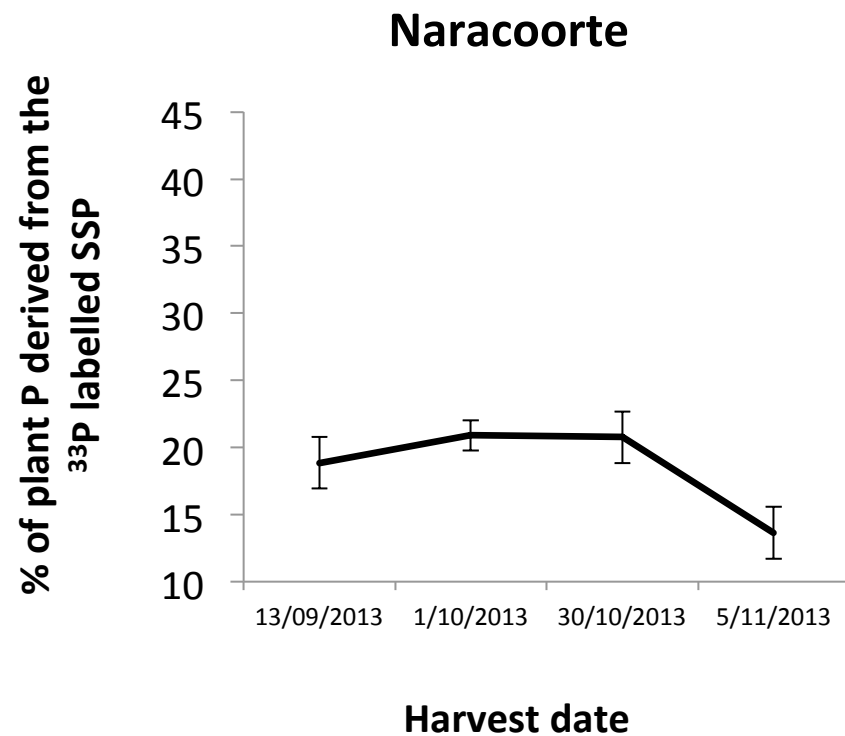
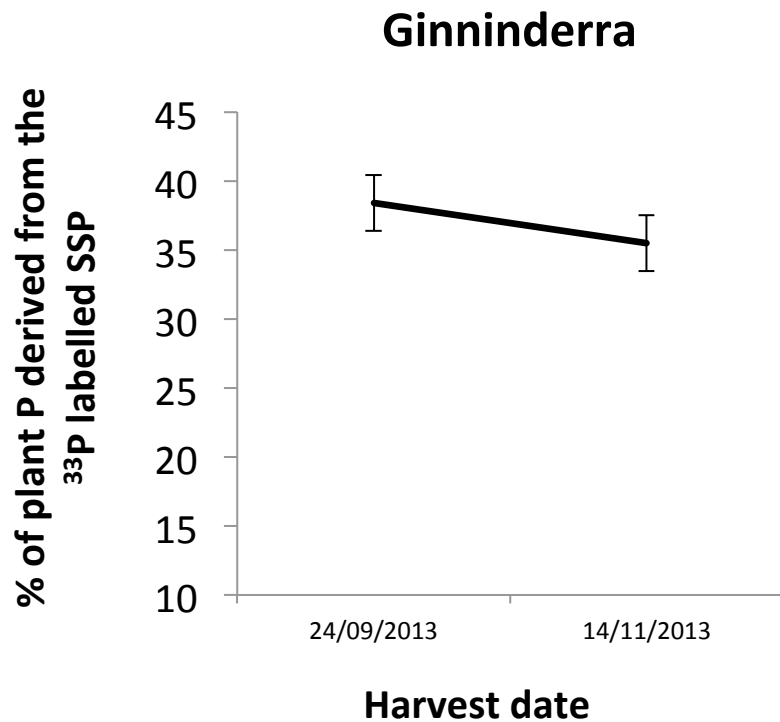
Dry matter and clover P uptake

- There was no significant difference between the control and ^{33}P labelled SSP treatments for total dry matter and total P uptake at both sites.

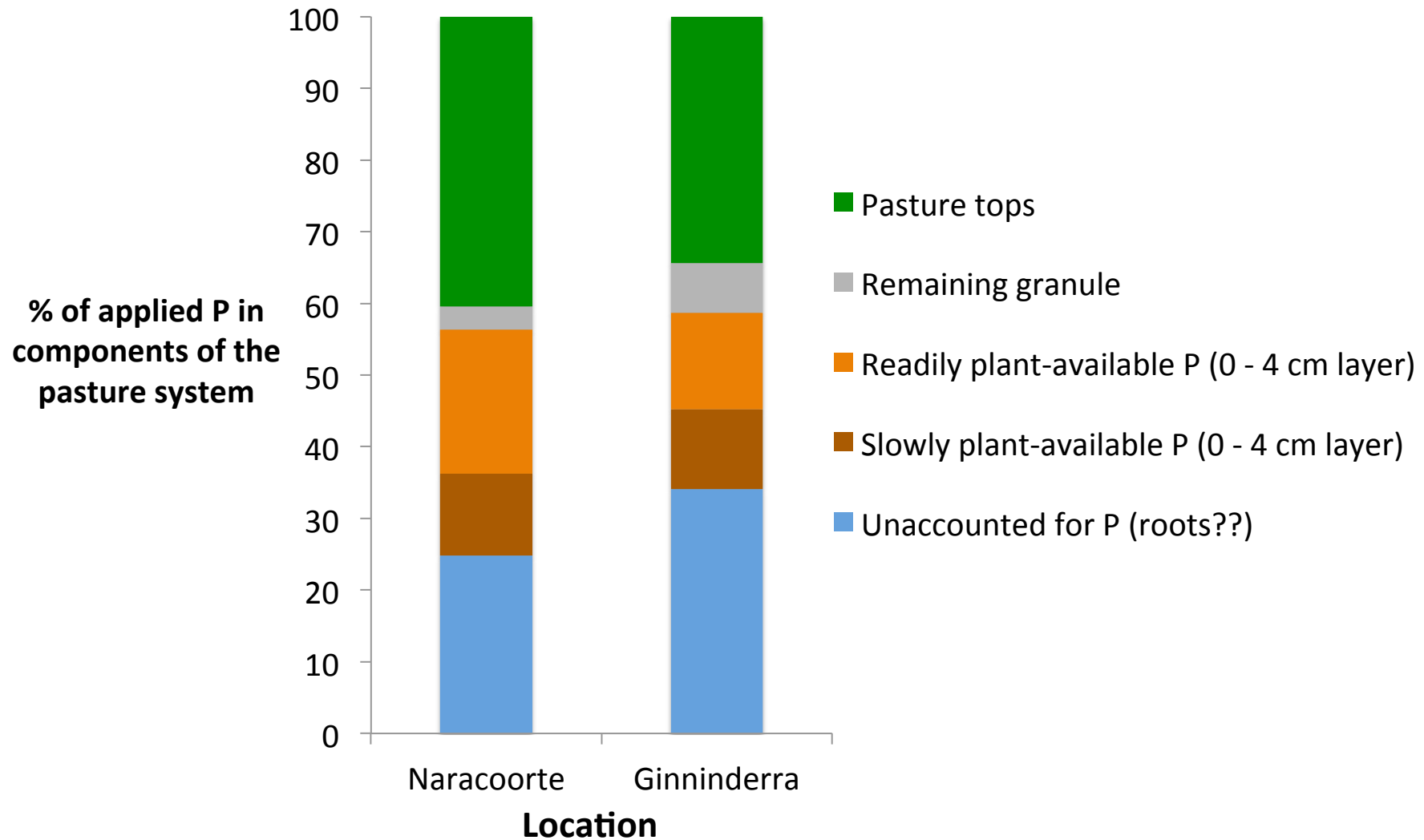
Measurement	Site	Control	^{33}P labelled SSP
Total dry matter (t DM ha ⁻¹)	Ginninderra	6.7 (0.5)	7.3 (0.5)
	Naracoorte	8.0 (0.5)	6.9 (0.6)
Total P uptake (kg P ha ⁻¹)	Naracoorte	28.4 (1.8)	28.1 (1.9)
	Ginninderra	7.8 (0.7)	10.5 (0.8)

Sourcing fertiliser P

- The proportion of plant P derived from the P fertiliser was almost double at the Ginninderra site than at the Naracoorte site.



The fate of fertiliser P in pastures



Fertiliser P in soil fractions

- Most fertiliser P recovered in NaHCO_3 and NaOH-EDTA extracts was P_i and in the 0 – 4 cm layer.
 - Less than 5 % of fertiliser P had moved into the 4 – 8 cm layer.
- Only a small amount (< 3 %) of the fertiliser P had accumulated as NaOH-EDTA extractable P_o in the 0 – 4 cm layer.



Conclusions

- 34 and 40 % of the fertiliser P was recovered in the clover tops at the Ginninderra and Naracoorte field sites.
- The proportion of clover P uptake that was derived from the P fertiliser was higher at the Ginninderra site than at the Naracoorte site.
- However, the soil was still the primary source of P for clover growth.
- Approximately 30 % of the fertiliser P was found in soil surface (0 – 4 cm), which was largely Pi.
- It is likely the remaining fertiliser P (~ 30 %) that was unaccounted for is contained within the root fraction; we are currently testing this hypothesis.

The bigger picture

- Phosphorus audits of long-term pasture soils often report high recoveries of fertiliser P (~ 90 %) in topsoil layers.
 - Hence, a low recovery by pastures is estimated (~ 10 %).
- Our results indicate that a relatively high proportion of fertiliser P is utilised by clover pastures, and when applied to pasture soils does not become rapidly unavailable to plants as previously thought.
- Therefore, it is likely that a considerable proportion of the fertiliser P used for pasture growth is actually recycled and returned to the soil surface.
- It also appears the accumulation of Po in pasture soils is through long-term processes.

Acknowledgements

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