Phosphorus-efficient pastures

Richard Simpson

7 May 2015
Why use P fertiliser?

1. to correct P-deficient soil
2. to grow more pasture
3. to get more clover
4. to reduce my tax bill
5. to run more stock & increase profit margins
P efficient pastures

(1) **Know your** target for soil P management

(2) Use soil tests to monitor & adjust fertiliser use

(3) Are there any other constraints?
Response of pasture to P

250 kg superphosphate/ha

Pasture growth (t DM/ha)

Colwell P = 30 (Olsen P = 15)

95% of max yield

“critical” fertiliser requirement
Response to superphosphate
(sub clover-rich pasture; Bookham, NSW)

Pasture growth rate
(% of max grth achieved in spring)

95% of max yield

Target for soil fertility management
("critical P" requirement)

Soil test value: Colwell P (mg/kg)
Phosphorus buffering index

- One-step measure of P sorption by a soil
- Allows target for soil P management to be predicted

Bookham Grazing Demonstration site

PBI = 80

Critical Colwell P value

(Better Fertiliser Decisions Project
Gourlay, Peverill, (Moody), et al.

Pasteure growth rate

Critical P

Colwell P (mg/kg)

Phosphorus buffering index (PBI)
When using Olsen P soil test

**critical P = 15 mg/kg**

*for all soil types*
Soil test value: Colwell P (mg/kg)

Pasture growth rate

Optimum soil fertility

Carrying capacity (DSE/ha)

6 DSE/ha

20 DSE/ha

Soil test value: Colwell P (mg/kg)

Optimum soil fertility

6 DSE/ha

20 DSE/ha
Soil P-fertility targets *that suit* your production goals
What to do if without a local pasture response curve?

Carrying capacity (DSE/ha)

Soil test value: Colwell P (mg/kg)

95% of max yield

Current position

Current soil test

Optimum P determined from PBI

6 DSE/ha

11 DSE/ha

16 DSE/ha

20 DSE/ha
P efficient pastures

(1) Know *your* target for soil P management

(2) **Use soil tests to monitor & adjust fertiliser use**

(3) Are there any other constraints?
Soil fertility build-up

Fertiliser applications (kg superphosphate/ha/year)

<table>
<thead>
<tr>
<th>Year</th>
<th>Colwell P (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993*</td>
<td>5</td>
</tr>
<tr>
<td>1994</td>
<td>7</td>
</tr>
<tr>
<td>1995</td>
<td>8</td>
</tr>
<tr>
<td>1996</td>
<td>10</td>
</tr>
<tr>
<td>1997</td>
<td>15</td>
</tr>
<tr>
<td>1998*</td>
<td>20</td>
</tr>
<tr>
<td>1999</td>
<td>15</td>
</tr>
<tr>
<td>2000</td>
<td>12</td>
</tr>
<tr>
<td>2001*</td>
<td>10</td>
</tr>
<tr>
<td>2002</td>
<td>15</td>
</tr>
<tr>
<td>2003</td>
<td>20</td>
</tr>
<tr>
<td>2004</td>
<td>25</td>
</tr>
<tr>
<td>2005</td>
<td>22</td>
</tr>
<tr>
<td>2006</td>
<td>20</td>
</tr>
<tr>
<td>2007</td>
<td>18</td>
</tr>
<tr>
<td>2008</td>
<td>15</td>
</tr>
<tr>
<td>2009</td>
<td>12</td>
</tr>
</tbody>
</table>

* Mo-super applied in these years

Target soil test range

Source: NSW DPI
Soil fertility build-up

Fertiliser applications (kg superphosphate/ha/year)

- Soil fertility build-up
- Maintenance phase

Colwell P (mg/kg)

Target soil test range

* Mo-super applied in these years
Soil fertility build-up

Fertiliser applications (kg superphosphate/ha/year)

- 250
- 125
- 65
- 125
- 90
- 0
- 85

Maintenance phase

Target soil test range

Colwell P (mg/kg)

- 0
- 5
- 10
- 15
- 20
- 25
- 30

* Mo-super applied in these years

Spring droughts
P efficient pastures

(1) Know *your* target for soil P management

(2) Use soil tests to monitor & adjust fertiliser use

(3) *Are there any other constraints?*
Is the balance of soil nutrients right?

*If soil has multiple nutrient deficiencies, the most limiting nutrient determines pasture yield.*

Control  -P  -Ca  -K  -Mg  -N
(all nutrients)

Annual ryegrass in unlimed topsoil from “Kia-Ora” (1 Sep. 03)
“Silvermere” via Taralga (PBI 300)
(pdk with P, K and S deficiencies)

Response to P with K & S applied

Response to P only

Pasture growth (kg/ha)

P application (kg P/ha)
Monaro Farming Systems “soils club” initiative

- Operating for 5 years (2010 – 2014)
- 66 farm businesses
- 893 Monaro paddocks now tested
MFS “soils club”: soil test results (2010-2014)

**Basalt soils**
- 22% below optimum for P
- 76% below optimum for S
- Adequate to high K levels

**Granite soils**
- 66% below optimum for P
- 78% below optimum for S
- 43% below optimum for K

*Some soils may benefit from lime*

**Shale soils**
- 75% below optimum for P
- 87% below optimum for S
- 36% below optimum for K

*Some soils may benefit from lime*
Know your own paddocks

**Paddock A**
- P deficient
- OK for S

**Paddock B**
- Moderate P defic
- Very S deficient

**Paddock C**
- Very high P
- Very S deficient

22% Phosphorus deficient
76% Sulphur deficient
Granite soil
(5-yr monitored pdks)

Colwell P (mg/kg)

Critical P

KCl40-S (mg/kg)

Critical S

“Swimming hole”

“Dog kennel”

1-Jan-10  1-Jan-11  1-Jan-12  1-Jan-13  1-Jan-14  1-Jan-15

1-Jan-10  1-Jan-11  1-Jan-12  1-Jan-13  1-Jan-14  1-Jan-15
Targeted use of $P$ – for more details…….

Five easy steps

to ensure you are making money from superphosphate

Booklet & computer tool available at: www.mla.com.au
Future opportunities (?)

Recent phosphorus price trends

Monthly average fertiliser price DAP (U.S. Gulf, fob/bulk)

Source: IFDC 2014
Efficiency of P use in Australian agriculture is low

Phosphorus Balance Efficiency

\[
PBE \ (\%) = \frac{P_{\text{output}}}{P_{\text{input}}} \times 100
\]

Median PBE (%)

- Cropping: 48%
- Dairy: 29%
- Beef: 19%
- Sheep: 11%

Average for grazing = 20%

5 units of P applied as fertiliser to produce

- 1 unit of P in animal products

= 4 units of P accumulated in farm paddocks

Weaver and Wong (2011)
Phosphorus accumulation in fertilised paddocks

Soil P fertility x grazing experiment
- run over 13 years at Ginninderra Expt Station, Canberra
Soil P management:

Soil test value
Olsen P (mg/kg)

over-fertilised: P2 (18 sheep/ha)
near-optimum: P1 (18 sheep/ha)
unfertilised: P0 (9 sheep/ha)
P cycle summary

- Optimum soil P management
  
  (P balance efficiency = 20%)

Wool production system (P1SR18, W3 expt), Canberra
The fate of fertiliser – P
(studies using $^{33}$P-labelled superphosphate)

Research team: Tim McLaren, Richard Simpson, Adam Stefanski, Mike McLaughlin, Ron Smernik, Therese McBeath, Chris Guppy, Alan Richardson

Univ. Adelaide, CSIRO, Univ. of New England

Funding: MLA & AWI
**P cycle summary** - Optimum soil P management

*(P balance efficiency = 20%)*

- **Fertiliser P**
  - 10 (kg P/ha)
- **Plant-available P**
  - 5 Poorly-available / accumulating P
- **Animal P**
  - Export in products
- **Accumulation in soil**
  - 7.5
- **Sheep camps**
  - 0.5
- **Wool production system (P1SR18, W3 expt) Canberra**
Soil P management:

Soil test value
Olsen P (mg/kg)

- **over-fertilised**: P2 (18 sheep/ha)
- **near-optimum**: P1 (18 sheep/ha)
- **unfertilised**: P0 (9 sheep/ha)

P fertility build-up  P fertility maintenance
Level at which soil P-fertility was maintained

(Olsen P; mg/kg soil)

Recommended optimum soil P level

P accumulation in grazed fields
(kg P/ha/year)

- 18 sheep/ha
- 9
Avoid over-fertilising

P accumulation in grazed fields (kg P/ha/year)

Level at which soil P-fertility was maintained (Olsen P; mg/kg soil)

Wrong way

Optimum soil P

Go back
Pastures with lower “critical P” requirements

P accumulation in grazed fields (kg P/ha/year)

Level at which soil P-fertility was maintained (Olsen P; mg/kg soil)

white clover or subterranean clover pasture

“low-P” legume

optimum soil P
A step-change in P-fertiliser costs?

P accumulation in grazed fields
(kg P/ha/year)

Level at which soil P-fertility was maintained
(Olsen P; mg/kg soil)

<table>
<thead>
<tr>
<th>Soil fertility level (Olsen P) (mg P/kg soil)</th>
<th>P accumulation in paddock (kg P/ha/year)</th>
<th>Estimated fertiliser input (kg P/ha/year)</th>
<th>Fertiliser saving (%)</th>
<th>P-balance efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>9.2</td>
<td>~11.2</td>
<td></td>
<td>18%</td>
</tr>
<tr>
<td>10</td>
<td>5.8</td>
<td>~7.8</td>
<td>~30%</td>
<td>26%</td>
</tr>
</tbody>
</table>
The search for “low critical P” legumes

Trifolium hirtum

Lotus corniculatus

Trifolium subterraneum

Field experiment (Yass, NSW)
French serradella

Herbage yield (spring harvest) (kg DM/ha)

Rate of P application (kg/ha)

Burrinjuck 2013

- French serradella
- sub clover
- yellow serradella

Burrinjuck 2014

- French serradella
- sub clover
- yellow serradella
Bolland and Paynter (1992) Western Australia yellow serradella (Ornithopus compressis) and subterranean clover (Trifolium subterraneum) herbage yield (t DM/ha) in response to P applied (kg/ha). The graph shows the herbage yield percentages at 95% max growth for both species. The black dots represent yellow serradella, and the black squares represent subterranean clover. The figure indicates that at 95% max growth, yellow serradella requires approximately 100 kg/ha of P applied, while subterranean clover requires slightly more, around 120 kg/ha. The study was conducted in Western Australia.
French serradella

Sub clover

no P fertiliser

mid range P fertility

Yass, 2014
Where to from here?

- Yield, persistence and proof of P savings in mixed pasture under grazing.

- Serradella adaptation range & persistence across paddock landscapes.
Acknowledgements:

National ‘P-efficient pastures’ project team:

Canberra: Richard Simpson, Rebecca Haling, Adam Stefanski, Zongjian Yang, & (Natalie Shadwell, Richard Culvenor, Rowan Alden)

Wagga Wagga: Graeme Sandral, Andrew Price, Shane Hildebrand, Chris Fuller & Wayne Pitt

Perth: Megan Ryan, Hans Lambers, Daniel Kidd, Rob Jeffery, Martin Barbetti & Phil Nichols

This research is funded by Meat and Livestock Australia, Australian Wool Innovation Ltd, and the collaborating research organisations.