Phosphorus (and sulphur) fertilizer for improved productivity of legume-based pastures

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Overview

Pastures and phosphorus in northern Australia
Reassess the paradigm that “P is adequate for pastures in the Brigalow belt”
P requirements for pastures and stock
Economics of applying P
Some general recommendations
Sown pastures in northern Australia

Majority of sown pastures are in Queensland (approx. 90%) (Walker & Weston 1990)

70% of total area planted to grass only (Walker & Weston 1990)

Buffel grass is the main species, >75% of area (Walker & Weston 1990)

Productivity has declined by ~50%
  – Due to ‘pasture rundown’ (nitrogen tie-up in soil organic matter)
  – Legumes are the best option to improve productivity but successful commercial adoption is low

• Largest areas of sown pastures in Queensland are in the Brigalow belt (Peck et al 2011)

• Very low use of fertiliser on pastures in northern Australia
Queensland’s Brigalow Belt:

30% of northern Australia’s beef herd on 15% of the grazed area

- Sown grass pastures
- Relatively fertile soils
- Moderate rainfall environment

Native pastures:
- Grass dominant
- Native legumes generally low production
Interim Biogeographic Regionalisation for Australia, Version 7

This map depicts the Interim Biogeographical Regionalisation for Australia (IBRA) version 7. IBRA regions represent a landscape based approach to classifying the land surface, including attributes of climate, geomorphology, landform, biogeography, and characteristic flora and fauna. Special ecological knowledge combined with appropriate regional and continental scale biophysical data sets were interpreted to describe these regions. 68 IBRA regions exist across Australia.
Productivity decline: N tie-up

Urea strip:

Productivity has declined by ~50% due to decreased nitrogen availability

RD&E results:

Legumes are the best option to improve productivity but successful commercial adoption is low
70% is P deficient for stock (Colwell <8mg/kg)

- P deficiency in stock in west and north = supplementation
- P is adequate (for stock) in the Brigalow Belt
- Fertilise in high rainfall zone, doesn’t pay elsewhere
- = almost nil fertiliser use in pastures in northern Australia
Leucaena fertiliser use

Survey of commercial properties (Radrizzani et al 2007):

- 58% reported declining productivity
- 10% used fertiliser at establishment
- 2% had used fertiliser in established pastures
Justification for P work in the Brigalow lands?

We’ve known for years that the Brigalow clay soils in southern and central Queensland have more than enough phosphorus for pastures and cattle…
Reality of P in the sub-tropics

P deficiency impact on cattle production

P levels are variable – soils databases, maps

Long histories of cropping = large removal of P (and other nutrients)

In the Brigalow Belt

- Only ~30% of soils have adequate P for all legumes
- ~20-30% of soils, all legumes will respond to P and stock may benefit from supplements

Pasture legumes respond strongly to P fertiliser

About one third of the northern Australian beef herd is in the Brigalow Belt
Intake of Energy, Protein & Phosphorus

P requirements related to protein and energy intake

High production – high requirement for P
Relative importance of nutrients for stock

METABOLISABLE ENERGY
PROTEIN
PHOSPHORUS
SULFUR
SODIUM
CALCIUM
VITAMINS
TRACE MINERALS
Annual liveweight gain of cattle and soil phosphorus status on legume-based pastures
Moura Grazing trial – Caatinga stylo 2011/12

Marginal P
Lower than expected growth rates at peak seasonal conditions
Wandoan grazing trial – Desmanthus 2011/12

P deficient
Copper marginal
Terrible growth rates
Legumes - “Huge potential”

Improved animal performance (diet quality)

- Stylos (native pastures): additional 40-60 kg/head/yr
- Leucaena: additional 60-90 kg/head/yr

Nitrogen fixation and cycling

- Leads to improved grass growth and better quality
  - 40-100% in “rundown” project trials
  - 10-30% in native pastures

Higher productivity

- Up to 60-160% increase in live-weight gain per hectare
- Doubling of gross margins
High production needs high legume content!

Rules of thumb:
• Need the paddock to look like about 50% legume

• >10% of total DM production to get an animal live-weight gain response
• 20-50% of total DM produced coming from the legume to maximise production
• > 4 plants /m² (depends on the size of individual plants of different legume species)
• Need good plant nutrition for high production
## P requirements for legumes

<table>
<thead>
<tr>
<th>Species</th>
<th>Critical P* (mg/kg)</th>
<th>Trial type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrubby stylo (cv Seca)</td>
<td>8</td>
<td>Field</td>
<td>(Gilbert and Shaw, 1987)</td>
</tr>
<tr>
<td>Caribbean stylo (cv Verano)</td>
<td>10 - 12</td>
<td>Field</td>
<td>(Probert and Williams, 1985; Hall, 1993)</td>
</tr>
<tr>
<td>Fine-stem stylo</td>
<td>??</td>
<td></td>
<td></td>
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<tr>
<td>Roundleaf cassia</td>
<td>??</td>
<td></td>
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<tr>
<td>Caatinga stylo</td>
<td>??</td>
<td></td>
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<tr>
<td>Desmanthus</td>
<td>??</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siratro</td>
<td>10 - 14</td>
<td>Field</td>
<td>(Rayment et al., 1977)</td>
</tr>
<tr>
<td>Butterfly pea (cv Milgarra)</td>
<td>25</td>
<td>Pot</td>
<td>(Haling et al. 2013)</td>
</tr>
<tr>
<td>Leucaena</td>
<td>&gt;15 - 25</td>
<td>Experience</td>
<td>Dalzell et al. 2006; Buck pers. comm.</td>
</tr>
<tr>
<td>Annual medics</td>
<td>12 - 30</td>
<td>Field</td>
<td>Rueter et al. 1995</td>
</tr>
</tbody>
</table>
Northern Australia beef industry P paradigm
Phosphorus availability under buffel grass pastures

Figure 5: Phosphorus availability (Colwell P) with time since clearing and burning of Brigalow forest (Thornton et al., 2010)
P reduction after cropping

Acid extractable P levels are:

As low as 20% of pre-cropping levels

Average of 68% of pre-cropping levels across southern and central Qld

Bell et al. 2010
Soil carbon project – soil P levels

Colwell P - 607 soils; BSES P – 604 soils.
– 255 Brigalow/belah/softwood scrub soils.

<table>
<thead>
<tr>
<th>P bicarbonate (0-10) mean 28 (1-280) mg/kg</th>
<th>ALL SOILS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No of soils</td>
</tr>
<tr>
<td>&lt; 4 mg/kg</td>
<td>14</td>
</tr>
<tr>
<td>4-6 mg/kg</td>
<td>53</td>
</tr>
<tr>
<td>7-9 mg/kg</td>
<td>71</td>
</tr>
<tr>
<td>10-15 mg/kg</td>
<td>134</td>
</tr>
<tr>
<td>16-25 mg/kg</td>
<td>130</td>
</tr>
<tr>
<td>&gt;25 mg/kg</td>
<td>205</td>
</tr>
</tbody>
</table>
Soils databases

Incitec Pivot Pty Ltd. and Qld government soils databases showed similar results:
- Incitec 31% Colwell less than 10; 39% >25mg/kg
- DNRM clay soils 56% <10; 26% >25mg/kg

For clay soils less than 10 mg P/kg (Colwell)

85% had low S (<5mg/kg MCP-S)
- If P and S is low apply single Superphosphate
- If only P required apply triple Super

Therefore solutions to low P need to consider S nutrition
Legumes respond strongly to P fertiliser

Caatinga stylo at Moura

After first summer

After 3rd summer

Dry Matter Production (kg/ha)

Phosphorus rate (kg P/ha)

DM response to P - 2013

DM response to P - 2015

+50%

+40%
Bio-economic modelling

Evaluate likely returns at the paddock scale from P fertiliser:

- 3 Soil fertilities – very low, low, moderate (Colwell P 4, 8 & 12 mg/kg)
- 3 legume critical P requirements – low, medium, high (Colwell 10, 15, 25 mg/kg)
- 2 fertiliser strategies – maximum legume yield or 75% of maximum
- 4 pasture situations:
  - Establishing legumes into existing grass-only pastures
  - Legume/grass pasture with low P requiring legume
  - Legume/grass pasture with medium P requiring legume
  - Legume/grass pasture with high P requiring legume
- With P supplements when Colwell <10 mg/kg
Economic analysis – 3 legumes, 3 soils, 2 fertiliser strategies

Internal rates of return
- 9-15% when establishing legumes into grass pastures on low P soils
- 12-24% when adding P fertiliser to already established grass/legume pasture
- 15-30% establishing legumes into high P soils
Economic analysis –
3 legumes, 3 soils, 2 fertiliser strategies

• Feeding supplements produced lower returns than fertiliser

• Total economic returns (NPV) often higher with high production/high P legumes;
  – Low P requiring legumes can provide similar or better marginal returns

• Fertilising for maximum yields produced higher returns
Recommendations for graziers

Understand importance of P

Assess P status

- Herd (blood/dung)
- Before establishing pasture legumes (soil test)
- Existing leucaena pasture (leaf test, soil test)

If P deficient, legumes + fertiliser

- Amount
- Frequency
- Placement
Legumes and phosphorus

- Fertilise the legume (P & S) to fertilise the grass (with N)
- Know the P requirement??
- All respond strongly to fertiliser P

- Establishment – soil tests
  - High P soils first
  - If required, apply fertiliser during fallow to incorporate

- Existing stands – soil test, leaf test if available
  - Still need soil test to know how much fertiliser

High live weight gain expectations… therefore high P demand for stock
Soil test recommendations

Available P – Colwell P

PBI
  • Adjust fertiliser rates and placement
  • High PBI – higher rates, banding

BSES P
  • Soils ability to resupply available P
Figure 8: Relationship between critical Colwell P and Phosphorus Buffering Index (PBI) of soils for temperate pastures based on subterranean and white clover collated nationally (Gourley et al., 2007).
“Use of phosphorus fertiliser for increased productivity of legume-based sown pastures in the Brigalow Belt region – a review”. Peck et al. 2015. MLA website

Very limited resources for tropical pastures – need RD&E

Good resources for temperate pastures, for example:

• “Five easy steps to ensure you are making money from superphosphate” – MLA website.
  – Good information on how much fertiliser how often
Conclusions

• Plant legumes
  – High P soils first
  – If low in P - fertilise

• P deficiency widespread in the Brigalow Belt (and elsewhere)

• Economic returns from legumes and P fertiliser are likely to be good

• Need adequate nutrition for legumes to be productive and succeed
  – Major change in attitude to fertiliser on pastures in northern Australia

• Persuasive argument for RD&E investment