Establishing pastures on acidic soils
Outline

- Which species to sow?
- Lime or acid tolerance?
- Pre-coated pasture seed
pH scale (in CaCl$_2$)
Possible effects of low pH

- Al toxicity
- Mn toxicity
- Reduced N-fixation
- Reduced nutrient availability (eg P, Mo)
- Increased nutrient availability (eg B, Co, Cu, Mg, Zn)
- Changed and reduced soil microbial activity

![Figure 2. Relationship between pH and exchangeable Al](image)

(Source: Guo et al. 2012)

$R^2 = 0.96$
Persistent pasture species – we don’t have many viable options

- Perennial legumes
  - Lucerne
- Perennial grasses
  - Phalaris
  - Cocksfoot
- Perennial herbs
  - Chicory
- Annual legumes
  - Subclover
Perennial pasture evaluation, Cootamundra 2004-08

Cumulative DM

Hayes et al. 2010; NZJAR 53, 283-302
Lucerne – The king of fodder

- Summer – active perennial species
- Legume – fixes N
- High quality forage
- Relies on longevity for persistence
- Upright growth habit
- Highly competitive for water
Limitations of lucerne

- Sensitive to acid soils
- Sensitive to waterlogging
- Sensitive to competition as a seedling
- Requires active grazing management
- Poorly adapted to shallow soils
- Low winter activity
Phalaris

- Changed recommendations for phalaris on acid soils
  – (Hayes et al. 2015)
Phalaris *Phalaris aquatica*

**Series:** Agnote DPI-284  **Edition:** Third edition  **Last updated:** 07 Apr 2004

**NOTE:** The information in this Agnote must be read in conjunction with Introduction to selecting and using pastures in NSW, which covers information on areas of adaptation, sources of variability, species mixtures, and important issues related to animal health and the conservation of native vegetation.

<table>
<thead>
<tr>
<th>Pasture type and use</th>
<th>Perennial autumn/winter/spring growing suited to dryland and irrigated grazing. Also used for hay and silage.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of adaptation</td>
<td>Northern, Central and Southern Tablelands; Central, Southern and Northern Slopes; irrigated areas and some limited coastal use.</td>
</tr>
<tr>
<td>Min. average annual rainfall</td>
<td>&gt;550 mm (southern NSW) to &gt;600 mm (northern NSW).</td>
</tr>
</tbody>
</table>

**Advantages**

- Very persistent and drought-tolerant temperate perennial grass.
- Competitive, robust plant capable of aiding in the control of many serious weeds such as serrated tussock, St John’s wort, nodding thistle.
- Vigorous sward habit useful for soil conservation purposes.
- Some varieties tolerant of prolonged heavy grazing.
- Good field tolerance to insects.
- Makes best growth in autumn and spring, with limited growth in winter.
- Tolerates wet soils, flooding and moderately saline soils.

**Disadvantages**

- Tends to be summer-dormant when temperatures exceed 30°C.
- Is not productive when soil fertility is low or declining.
- Is not suited to very acid soils (establishment on soil pH(Ca) below 5.0 is not as reliable as cocksfoot, fescue or ryegrass).
- Requires good grazing management to maintain grass–legume balance and soil quality.
The need for a revision; Goulburn

- 7 pasture treatments
  - Phalaris
  - Cocksfoot
  - Tall fescue
  - Grazing brome
  - Yorkshire fog
  - Chicory
  - Birdsfoot trefoil

- 2 lime treatments
  - Nil
  - 3.5 t/ha

Pasture experiment sown at Middle Arm in 2005 (Reported in Hayes et al. 2010)
Key message from Goulburn site

- Phalaris was THE only species to persist in the absence of lime
  - Suggesting it was tolerant of acidic soils

Phalaris, Nil lime treatment
Pasture persistence at Gerogery

Basal frequency (%) in year 3

Basal frequency (%) in year 4

Nil Lime

Lime
Solution culture experiment

- 8 phalaris, 7 cocksfoot & 4 fescue genotypes were grown as seedlings in solution at 5 concentrations of Al.
- Reduction in cocksfoot root length (67%) was less than the other grasses (82%).
- Cocksfoot started from a lower base.

Song et al. (2015)
Solution culture experiment

- Root length of phalaris = cocksfoot at maximum stress
- Does this put phalaris at a disadvantage in the field?
- Could phalaris be at an advantage over cocksfoot at lower Al concentrations?

Song et al. (2015)
Recommendations

- Conventional wisdom
- Phalaris not suited to:
  - Soils pH_{Ca} < 5.0 (Anon 2004)
  - Soils pH_{Ca} < 4.9 (Lake 2000)
  - Al saturation ≥ 10 % (Duncan 1999)

- Proposed thresholds:
- All phalaris cultivars should tolerate
  - pH_{Ca} > 4.2
  - Al saturation < 20%
- Landmaster and Advanced AT can tolerate
  - pH_{Ca} > 3.9
  - Al saturation 30-50%
Cocksfoot

- Adapted to shallow and lower fertility soils
- Generally higher crude protein and DMD than phalaris and tall fescue
  - Hayes et al. 2010; NZJAR 53, 283-302
Chicory

- Perennial herb – not a legume
- Needs to be sown with a legume – not lucerne – Li et al. 2012
- Quicker to establish, but not as long-lived as lucerne
- V. high quality forage
- Lower winter activity than lucerne
Why not tall fescue?

Table 1. Basal frequency of perennial grasses at 2 sites, 2006-08

<table>
<thead>
<tr>
<th>Species/cultivar</th>
<th>Cootamundra</th>
<th></th>
<th></th>
<th>Wagga Wagga</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocksfoot (cv. Kasbah)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>45</td>
<td>23</td>
<td>6</td>
</tr>
<tr>
<td>Cocksfoot (cv. Currie)</td>
<td>42</td>
<td>7</td>
<td>6</td>
<td>34</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Tall fescue (cv. Demeter)</td>
<td>23</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tall fescue (cv. Fraydo)</td>
<td>39</td>
<td>25</td>
<td>7</td>
<td>22</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Phalaris (cv. Landmaster)</td>
<td>30</td>
<td>32</td>
<td>7</td>
<td>24</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>l.s.d. (P = 0.05)</td>
<td>16.0</td>
<td>8.8</td>
<td>3.9</td>
<td>10.0</td>
<td>10.5</td>
<td>3.8</td>
</tr>
</tbody>
</table>
Relative herbage yield, 2004-08

- Cootamundra: +97%
- Wagga: +138%

Phalaris
Fescue
Annual legumes for long-term pasture phases

- Subclover
  - Highly acid tolerant
  - Highly grazing tolerant
  - Low-moderate levels of hard seed
  - Many cultivars available adapted to a range of environments
Alternative legumes?
Goulburn 2013 – Frequency sampled
Sep 2016

Hayes et al. 2015
The lime story

- Lime is an old story
  - Acid soil ‘bible’ published in 1989
- Lime is an ameliorant, **not** a fertiliser
- Agriculture is typically acidifying; on acid soils maintenance applications of lime are required
- Lime can improve productivity substantially
  - At a minimum should be applied prior to sowing
Lime experiment

- Sown at Gerogery, 2004
- Neutron probe access tubes installed to 3 m
- 5 year run of data; to Sep 2008
- 2 lime treatments; nil & 2.9 t/ha
- 5 pasture treatments;
  - Lucerne cv. Aurora (HS)
  - Phalaris cv. Landmaster (S)
  - Chicory cv. Puna (T)
  - Tall fescue cv. Fraydo (MT)
  - Cocksfoot cv. Currie (HT)
Effect of lime on seasonal biomass production

Available biomass (t/ha)

<table>
<thead>
<tr>
<th>Season and year</th>
<th>Nil Lime</th>
<th>Lime</th>
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</thead>
<tbody>
<tr>
<td>Spr 04</td>
<td>(17)</td>
<td></td>
</tr>
<tr>
<td>Aut 05</td>
<td>(40)</td>
<td></td>
</tr>
<tr>
<td>Win 05</td>
<td>(23)</td>
<td></td>
</tr>
<tr>
<td>Spr 05</td>
<td>(26)</td>
<td></td>
</tr>
<tr>
<td>Sum 05</td>
<td>(59)</td>
<td></td>
</tr>
<tr>
<td>Aut 06</td>
<td>(17)</td>
<td>(26)</td>
</tr>
<tr>
<td>Win 06</td>
<td>(24)</td>
<td>(23)</td>
</tr>
<tr>
<td>Sum 06</td>
<td>(40)</td>
<td>(24)</td>
</tr>
<tr>
<td>Aut 07</td>
<td>(54)</td>
<td>(24)</td>
</tr>
<tr>
<td>Win 07</td>
<td>(23)</td>
<td>(40)</td>
</tr>
<tr>
<td>Sum 07</td>
<td>(17)</td>
<td>(23)</td>
</tr>
<tr>
<td>Aut 08</td>
<td>(35)</td>
<td>(62)</td>
</tr>
<tr>
<td>Win 08</td>
<td>(69)</td>
<td>(40)</td>
</tr>
</tbody>
</table>

Numbers in brackets indicate the percentage increase in available biomass due to lime at a given sampling time; ns – differences not significant at P = 0.05; * - a significant species x lime interaction was observed at that sampling time.

Av. = 38% ↑
Deep soil water

Figure 12. Changes of soil water deficit (mm) from October 2005 to July 2008 at 0.15-0.60 m and 0.75-1.65 m below the soil surface on plots with and without surface lime application sown to phalaris. (Source: Hayes et al. 2016)
Summary

- Few species options for improved pastures
  - Lucerne – the gold standard but sensitive to acidity
  - Phalaris – well adapted to acidic soils
  - Cocksfoot – well adapted to shallow soils
  - Chicory – a useful shorter term forage
  - Subclover – The universal companion legume
- Lime improves productivity of improved pastures often by ~30%
- Lime increases utilisation of the soil water resource
Pre-coated pasture seed

- Bare phalaris: 153 seeds = 0.26g
  - 1000 sw = 1.70g
- Coated phalaris: 166 seeds = 1.02g
  - 1000 sw = 6.14g
- Coated seed was 3.6 times heavier than bare seed
- 1.5 kg sowing rate need to increase to 5.4 kg/ha
  - Seed costs would increase from $121/ha to $436/ha
Pre-coated pasture seed

- Actual sowing rate reduced to 0.42 kg/ha
- Lime (5t/ha) was purchased prior to sowing @ $53/t landed
  - Lime on the seed coat was ≈ $15 000/t
Pre-coated pasture seed

- Adds to then unit cost of seed
  - Content of coat often unknown
- Very short shelf life (6 weeks for subclover)
- Survival of N-fixing bacteria variable and often poor
  - (Gemmell et al. 2005)
- Lack of information about other components of seed coats (e.g., fungicides/insecticides)
- Lack of data supporting the use of seed coats

MY SUGGESTION: Don’t use pre-coated pasture seed without a specific justification