Research for sustainable intensive dairy farming: focus on phosphorus

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AgResearch - Invermay
The challenge

- Eutrophication
  - N vs. P
  - Source to impact site
## Typical phosphorus losses

<table>
<thead>
<tr>
<th>Site</th>
<th>Loss (kg P ha(^{-1}) y(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southland milking platform</td>
<td>1.0 - 1.5</td>
</tr>
<tr>
<td>- effluent block</td>
<td>1.3 - 4.5</td>
</tr>
<tr>
<td>Waikato dairy farm</td>
<td>1.0 - 2.5</td>
</tr>
<tr>
<td>Canterbury dairy farm</td>
<td>0.3-0.5</td>
</tr>
<tr>
<td>Dairy catchment losses</td>
<td>0.3 – 8.5</td>
</tr>
<tr>
<td>Deer catchment losses</td>
<td>0.3 – 4.0</td>
</tr>
<tr>
<td>Sheep catchment losses</td>
<td>0.1 – 0.8</td>
</tr>
<tr>
<td>New Zealand mean</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Phosphorus issues facing a typical dairy farm

- Dung and effluent
- Soil
- Fertiliser
- Wintering
- Drainage / irrigation
- Timing and spatial management
**P loss from soil**

- **Waikīwi (Brown soil)**
- **Woodlands (Brown soil)**

**Critical value for P loss**

**“the gap”**

- **Hari Hari**
  - P retention ~ 35%

- **Okarito, Hokitika**
  - P retention < 20%

**Critical value for yield**
P loss from soil

Let soil Olsen P decline by having a negative soil P balance

• How long does each soil in a catchment take for Olsen P to decline to safe concentrations and what is the safe strategy?

Farm systems

• Is clover high-P and ryegrass low-P better than clover/ryegrass high P?

Addition of P sorption agents: e.g., by-products

• Paddock application or in-stream

Relocate areas of high potential P losses to non-CSAs
P loss from fertiliser

Days after application

Dissolved reactive P concentration (mg L$^{-1}$)

Superphosphate

Serpentine super

Reactive phosphate rock
## P loss from fertiliser

<table>
<thead>
<tr>
<th>Application date</th>
<th>Superphosphate</th>
<th>RPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002 June</td>
<td>0.24</td>
<td>0.01</td>
</tr>
<tr>
<td>2002 December</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>2003 June</td>
<td>0.23</td>
<td>0.01</td>
</tr>
<tr>
<td>2003 December</td>
<td>0.09</td>
<td>0.01</td>
</tr>
</tbody>
</table>

P loss from application of 30 kg P/ha/yr ($\pm$ 0.02)
P loss from dung / effluent

Days after manure application

Total P (mg L⁻¹)

Cropland

Pasutre

0 1 2 3 4 5

0 1 2 3
P loss from effluent

Timing
Placement
Storage

Monthly P loss from irrigation of 130 mm effluent

<table>
<thead>
<tr>
<th>Application date</th>
<th>5% effluent block</th>
<th>10% effluent block</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>1.8</td>
<td>1.3</td>
</tr>
<tr>
<td>December</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>1.6</td>
<td>1.2</td>
</tr>
<tr>
<td>December</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Sources of phosphorus loss from Tussock Creek

Contribution to farm discharges:

- Soil
- Dung
- Fertiliser

2002 2003
Sources of phosphorus loss from Rotomanu H&H

Site M0

2004

2005

Site M7
Options for mitigating phosphorus losses

Soil amelioration
  • Decrease soil Olsen P to 30 mg kg\(^{-1}\) unless in top 20% of producers for the region
  • Cultivation and soil mixing as part of farm re-grassing program or addition of P sorption agents

Fertiliser P loss mitigation
  • Use RPR or serpentine super.
  • Avoid applying superphosphate if rain forecast within the next 7 days.

Effluent/dung P loss mitigation
  • Only apply effluent when soil dry, increase storage and use K-line.
  • Use feed-pad / wintering pad.
## Options for mitigating phosphorus losses

### Net costs of BMPs

<table>
<thead>
<tr>
<th>Option</th>
<th>Cost Range (per cow per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deferred irrigation &amp; K-line</td>
<td>$&lt;4</td>
</tr>
<tr>
<td>Wintering pads</td>
<td>$-5$ to $44$</td>
</tr>
<tr>
<td>Optimum Olsen P</td>
<td>$-15$ to $-22$</td>
</tr>
</tbody>
</table>
## Effective managements?

<table>
<thead>
<tr>
<th>Strategy/treatment</th>
<th>Dissolved P loss (kg P ha(^{-1}) or %)</th>
<th>Total P loss (kg P ha(^{-1}) or %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructed wetland</td>
<td>-92 to 85%</td>
<td>-426 to 77%</td>
</tr>
<tr>
<td>Effluent irrigation with aeration</td>
<td>-</td>
<td>70</td>
</tr>
<tr>
<td>K-line irrigation</td>
<td>-</td>
<td>75</td>
</tr>
<tr>
<td>Sedimentation pond</td>
<td>10</td>
<td>33</td>
</tr>
<tr>
<td>RPR</td>
<td>60</td>
<td>25</td>
</tr>
<tr>
<td>Restricted grazing of cropland</td>
<td>10</td>
<td>75</td>
</tr>
<tr>
<td>Amendment in drainage</td>
<td>80</td>
<td>75</td>
</tr>
<tr>
<td>Amendment in streamflow</td>
<td>31</td>
<td>15</td>
</tr>
</tbody>
</table>
Source areas

Risk
Low (clear)
Medium
High
Potential transport areas

Risk
- Low (clear)
- Medium
- High
Critical source areas of P loss

~90% of loss comes from <20% of catchment

Risk
Low (clear)
Medium
High