Optimising soil fertility leads to efficient fertilizer use

Tim S. Sheil\textsuperscript{1} Stan T.J. Lalor\textsuperscript{2} and David. P. Wall\textsuperscript{3}

\textsuperscript{1}Alltech Bioscience Centre, Dunboyne, Co Meath
\textsuperscript{2}Grassland Agro, Dock Road, Limerick
\textsuperscript{3}Teagasc, Johnstown Castle, Wexford

Catchment Science  2015
Presentation outline

Background

Laboratory incubation study

Long term P experiment

Multisite field experiment

Soil P and lime interaction

Seasonal and annual effects of P

N, P and lime interaction

Catchment Science 2015
Perennial problem

Food harvest 2020
Production - High Yield & High Quality

Catchment Science 2015
Phosphorus use stats (Ireland)

Phosphorus fertilizer usage in Ireland (tonnes P)

<table>
<thead>
<tr>
<th>Year</th>
<th>P fertilizer Input</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>60000</td>
<td>200</td>
</tr>
<tr>
<td>1992</td>
<td>50000</td>
<td>300</td>
</tr>
<tr>
<td>1996</td>
<td>40000</td>
<td>400</td>
</tr>
<tr>
<td>2000</td>
<td>30000</td>
<td>500</td>
</tr>
<tr>
<td>2004</td>
<td>20000</td>
<td>600</td>
</tr>
<tr>
<td>2008</td>
<td>10000</td>
<td>700</td>
</tr>
</tbody>
</table>

Catchment Science 2015
Soil test P trends
2013 Data

Good Overall Fertility - Tillage:
Soil pH > 6.5; Soil P and K Index 3 or 4

- Optimum: 14%
- 86%

Catchment Science 2015
Laboratory incubation study

Objective – How do soils differ in the response to addition of P and lime

16 soils chosen with contrasting soil texture, soil P levels (Morgan’s) and soil pH

**Soils** incubated in pots
- Bulk density
- Constant moisture content
- Temperature
- Constant humidity

<table>
<thead>
<tr>
<th>Treatments</th>
<th>No Lime</th>
<th>+ Lime (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No P</td>
<td>0/0</td>
<td>0/5</td>
</tr>
<tr>
<td>+ P (kg/ha)</td>
<td>100/0</td>
<td>100/5</td>
</tr>
</tbody>
</table>

Catchment Science  2015
1. Only 4 - 31 % of fertilizer P is recovered in the STP
2. Lime also increased the STP
3. Additive benefits of P and lime
Influence of Aluminium

Catchment Science  2015
Presentation outline

- Background
- Laboratory incubation study
- Long term P experiment
- Soil P and lime interaction
- Seasonal and annual effects of P

Catchment Science 2015
**Objective**
Examine the effect of P fertilizer on seasonal and annual grass production and herbage P concentration

**Experimental design**
JC dairy farm in 1995
clay loam (site 1)
sandy loam (site 2)

Phosphorus (16% TSP) 0, 15, 30, 45 kg ha yr\(^{-1}\)

**Harvest**
Between 6 and 8 harvests a year - DM yield and P concentration in herbage
Long term P experiment results (17 years)

**DM Yield**

14% increase in the herbage yield

*Catchment Science 2015*
Long term P experiment (effect of harvest)

Catchment Science 2015
Long term P experiment results (17 years)

Herbage P concentration

Catchment Science 2015
Presentation outline

- Background
- Laboratory incubation study
- Long term P experiment
- Multisite field experiment
- Soil P and lime interaction
- Seasonal and annual effects of P
- N, P and lime interaction
Multisite field trial

Objective – Soil fertility effect on grass production (N, P, Soil pH)

2 sites
Johnstown, Wexford (JC)
Moorepark, Cork (MP)

Treatments
4x3x2 Factorial design = 24 plots (4 reps)

Phosphorus - 0, 20, 40, 60 kg ha yr\(^{-1}\)
Nitrogen - 0, 150, 300 kg ha yr\(^{-1}\)
Lime - 0, 5 t ha (applied in year 1)

2011 - 4 harvests (Jun -Nov)
2012 - 8 harvests (full year)
Multisite field trial results

Cumulative herbage yield - Site 1

Phosphorus
5.5% increase in the herbage yield
(1214 kg DM ha\(^{-1}\))

Lime
3% increase in herbage yield
(568 kg DM ha\(^{-1}\))
Multisite field trial results

Phosphorus:
5.7% increase in the herbage yield
(1244 kg DM ha\(^{-1}\))

Lime:
2% decrease in herbage yield
(-526 kg DM ha\(^{-1}\))
When was response to P most evident

| Harvest | Site 1 |          | |          | Site 2 |          | |
|---------|--------|----------||----------|--------|----------||
|         | N      | P        | Lime | N        | P        | Lime |
| 1.1     | <.0001 | **0.0004** | 0.3966 | 0.0082 | **0.0246** | 0.0784 |
| 1.2     | <.0001 | 0.7721   | 0.7115 | <.0001 | 0.7608   | 0.3612 |
| 1.3     | <.0001 | 0.1758   | 0.6265 | <.0001 | 0.1008   | 0.5712 |
| 1.4     | <.0001 | 0.1981   | **0.0242** | <.0001 | 0.567    | 0.7082 |
| 2.1     | **0.0135** | 0.1256 | 0.726 | 0.0049 | 0.6002 | **0.0073** |
| 2.2     | <.0001 | **0.0267** | 0.0482 | <.0001 | 0.2007 | 0.1123 |
| 2.3     | <.0001 | 0.8826   | **0.0019** | <.0001 | 0.1446 | 0.2089 |
| 2.4     | <.0001 | 0.0804   | 0.3059 | <.0001 | **0.0362** | 0.113 |
| 2.5     | <.0001 | 0.0704   | 0.0849 | <.0001 | 0.0911 | **0.0274** |
| 2.6     | <.0001 | 0.5746   | 0.1509 | <.0001 | 0.4395 | 0.0774 |
| 2.7     | <.0001 | 0.1885   | 0.1706 | <.0001 | 0.117   | 0.2928 |
| 2.8     | <.0001 | 0.7386   | **0.0211** | <.0001 | 0.1016 | 0.1408 |
## Herbage P Interactions

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Site 1</th>
<th>Site 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N*P</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$N_0$</td>
<td>0.36</td>
<td>0.37</td>
</tr>
<tr>
<td>$N_{150}$</td>
<td>0.33</td>
<td>0.34</td>
</tr>
<tr>
<td>$N_{300}$</td>
<td>0.31</td>
<td>0.34</td>
</tr>
<tr>
<td><strong>Lime*P</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$L_0$</td>
<td>0.34</td>
<td>0.36</td>
</tr>
<tr>
<td>$L_5$</td>
<td>0.33</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Not significant
Summary

- **Laboratory incubation**
  - Lime will reduce P requirement

- **Long term P experiment**
  - 15% yield increase + mid season drop

- **Multisite field experiment**
  - P for early growth and maintain herbage P content
Perennial Problem – Sustainability

1. P fertilizer and lime go hand in hand for maximising grass production

2. Addressing soil fertility and placing N and P fertilizer where it is needed most will reduce environmental impact

3. Nutrient management planning – essential
Research to Advice

The work of this project is contributing to development of Teagasc Soil Fertility Management Advice & Knowledge Transfer initiatives

Acknowledgments

Supervisors
Technicians
Farmers
Students