Enhanced Nitrogen Use Efficiency in Sugar Cane

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Nutrient Management

- Choice of Product
- Rate of Application
- Application method
- Frequency of Application
- Timing of method

4R: Right Source, Rate, Time & Place
N Losses highly influenced by

- Rainfall
- Temperature
- Soil type
- Stage of crop growth
- etc etc
Enhanced Efficiency Fertilizers

- Controlled / slow release
- Urease inhibitors
- Nitrification inhibitors
Controlled Release Fertilisers

- Inorganic, low solubility (MgNH$_4$SO$_4$; RRP)
- Organic, low solubility (urea formaldehyde (UF), Super sized urea)
- Physical barrier (coated fertilisers)

eg. polymer, sulfur, zeolite, humic acid, lipids, Osmocote®, Multicote, Acticote, Meister

Double coated – sulfur/polymer

Moisture & temperature
Coating thickness
Controlled Release Fertilisers

Nutrient release from CRF granules (soil based)

(Urea remaining in granules (%))

Time (days)

sulfur
lipid
polymer

(Ireland et al., 2012)
N leaching rates under potato (Florida)


- Field grown potato (var. Atlantic) in a sandy soil.
- N applied at 146 kg N/ha & 225 kg N/ha at planting, + N free control.
- Nitrate concentrations in lysimeters was measured every two weeks for 12 weeks after fertiliser application.
N leaching rates under potato (Florida)

Nitrate leaching under mature Citrus on a sandy soil (Florida)


- 21 year old orange trees on mandarin rootstock
- Sandy soil

<table>
<thead>
<tr>
<th>Fertiliser</th>
<th>Method</th>
<th>Split applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertigated AN</td>
<td>Micro-sprinkler</td>
<td>15</td>
</tr>
<tr>
<td>Granular AN</td>
<td>Broadcast</td>
<td>4</td>
</tr>
<tr>
<td>Controlled release urea</td>
<td>Broadcast</td>
<td>1</td>
</tr>
</tbody>
</table>
Nitrate leaching under mature Citrus on a sandy soil

Urea hydrolysis:
\[
\text{Urea (CO(NH}_2)_2} + \text{H}_2\text{O} \rightarrow (\text{NH}_4)_2\text{CO}_3 \rightarrow \text{NH}_4^+ \rightleftharpoons \text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O}/\text{OH}^-
\]

Urease Inhibitors

pH dependent

## Urease inhibitors

<table>
<thead>
<tr>
<th>Class</th>
<th>Example inhibitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>react with sulfhydryl group</td>
<td>hydroquinone (HQ)</td>
</tr>
<tr>
<td>complex with Ni</td>
<td>acetohydroxamate (AHA)</td>
</tr>
<tr>
<td>structural analogue of urea</td>
<td>N-(n-butyl) phosphoric triamide (NBPT)</td>
</tr>
<tr>
<td></td>
<td>cyclohexylphosphoric triamide (CHPT)</td>
</tr>
<tr>
<td></td>
<td>phenylphosphorodiamidate (PPD)</td>
</tr>
<tr>
<td>crop protection chemicals</td>
<td>Diazinon</td>
</tr>
<tr>
<td>natural products</td>
<td>Neem, coal tar</td>
</tr>
</tbody>
</table>

Urease inhibitor and urea hydrolysis

![Graphs showing urea remaining over days after fertiliser application for clay loam and clayey sand.](image)

<table>
<thead>
<tr>
<th></th>
<th>Clay loam</th>
<th>Clayey sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5.5</td>
<td>7.3</td>
</tr>
<tr>
<td>Clay</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>Organic C (%)</td>
<td>3.9</td>
<td>0.5</td>
</tr>
<tr>
<td>Urease activity (mg urea-N/g soil/hr)</td>
<td>134</td>
<td>43</td>
</tr>
<tr>
<td>Land use</td>
<td>pasture</td>
<td>cropping</td>
</tr>
</tbody>
</table>

Suter et al. (2011)
Nitrification inhibitors

Soil

- Region
- pH
- C content and forms
- Texture and structure
- Moisture content
- Temperature

SOIL

NH$_4^+$

$\rightarrow$ $\rightarrow$

NH$_2$OH

NO$_2^-$

$\rightarrow$ $\rightarrow$

NO$_3^-$

Bacteria, Archaea, Funghii

Proxy for soil microbial community
<table>
<thead>
<tr>
<th>Compound</th>
<th>Name</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrapyrin</td>
<td>N-serve™ eNtrench™</td>
<td>Volatile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-volatile formulation, commercially available</td>
</tr>
<tr>
<td>Dicyandiamide (DCD)</td>
<td>Alzon ®46</td>
<td>commercially available</td>
</tr>
<tr>
<td>3, 4-dimethylpyrazole phosphate (DMPP)</td>
<td>ENTEC ®</td>
<td>commercially available</td>
</tr>
<tr>
<td>Etridiazole</td>
<td>Terrazole ®</td>
<td>Fungicide, liquid</td>
</tr>
<tr>
<td>2EP (2-ethynypyridine)</td>
<td></td>
<td>effective but costly</td>
</tr>
<tr>
<td>3MP+TZ</td>
<td>PIADIN ®</td>
<td>limited studies, commercially available</td>
</tr>
<tr>
<td>Neem cake/oil</td>
<td>NIMIN ®</td>
<td>limited studies</td>
</tr>
<tr>
<td>Actylene</td>
<td></td>
<td>gas</td>
</tr>
<tr>
<td>Natural Nitrification Inhibitors (NNI)</td>
<td></td>
<td>Plant root exudates, seed oil etc. limited studies</td>
</tr>
</tbody>
</table>
Pasda, Hahndel & Zerulla, 2001

• Reviewed 136 DMPP trial from Europe
• Wheat +0.25 t/ha
• Rice +0.29 t/ha
• Maize (grain) +0.24 t/ha
• Potatoes + 1.9 t/ha
• Sugar beet (sugar) +0.24 t/ha
• In some crops the same yield with less N
• Positive yield more pronounced at sites with high precipitation or irrigation, and/or light sandy soil.
Background

- EEF historically use in turf and ornamental horticulture
- Relative cost has narrowed
- Different modes of action
- Know dominate loss pathway critical in choosing product
- Climatic variation in GBR catchments is high
Key Points

- EEF may contribute to improved NUE, but will end of catchment DIN be reduced?
- Most of the Aust data focused on agronomic benefits
- Little Aust data on reduced off-site impacts, particularly surface & deep drainage losses
- Can overseas data be relied on???
- Fert industry has invested & will continue to invest in quantifying agronomic performance
- Unlikely to pay for quantification of environmental performance of EEF in NQ
Key Points

- EEF highly likely to improve NUE
- Hypothesis: improving NUE will improve water quality leaving cane fields & end of catchment DIN
- Local, independent, science based evidence required:
  - Assist natural resource managers predict effect of EEF on end of catchment DIN
  - Farmers & advisors make informed decision on agronomic, economic & environmental outcomes of EEF