Smart Blending of Enhanced Efficiency Fertilisers for Sugarcane

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Incitec Pivot, Everris International.
Fate of Fertiliser $^{15}$N* in Sugarcane Farming Systems

<table>
<thead>
<tr>
<th>Location</th>
<th>Crop $^{15}$N %</th>
<th>Soil $^{15}$N %</th>
<th>$^{15}$N loss %</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Johnstone‡</td>
<td>30</td>
<td>24</td>
<td>46</td>
</tr>
<tr>
<td>Mackay‡</td>
<td>27</td>
<td>23</td>
<td>51</td>
</tr>
<tr>
<td>Childers‡</td>
<td>29-39</td>
<td>19-38</td>
<td>28-53</td>
</tr>
<tr>
<td>Broadwater§</td>
<td>17</td>
<td>17-42</td>
<td>41-66</td>
</tr>
<tr>
<td>Harwood§</td>
<td>29</td>
<td>24</td>
<td>47</td>
</tr>
</tbody>
</table>

* $^{15}$N-labelled urea at ~160 kg N/ha; buried below ~5 cm
‡ Green cane harvesting
§ Burnt cane harvesting
Factors and processes for low NUE

- Soil mineral N (NH$_4^+$ → NO$_3^-$)
- Crop N uptake
- Urea Fertilisation

Time (months)
Factors and processes for low NUE

- Urea application
- Soil mineral N (NH$_4^+$ ↔ NO$_3^-$)
- Crop N uptake

Time (months)
EEFs and potential benefits of blended use

- Urease inhibitor (UI; e.g., Green Urea)
- Nitrification inhibitor (NI; e.g., Entec)
- Double inhibitors (DI)

- Slow- or controlled-release fertiliser (urea)
  - Less soluble compounds (urea formadehyde, IBDU)
  - Sulphur coating
  - Wax coating
  - Polymer coating (PCU) → Biodegradable

- Benefits of blended use of PCU
  - Reducing cost
  - Better match crop N demand?
Project objectives

- Assess the benefits of EEFs vs. urea (cane yield, sugar yield, soil N supply, plant N uptake, NUE, profitability);
- Can EEFs significantly reduce fertiliser N application rates?
- What is the optimal blending ratio of PCU to urea in relation to site and seasonal conditions?
Field trial sites and seasons (10/2016 – 10/2019)

Cropping season:
• 2016-2017
• 2017-2018
• 2018-2019

- Innisfail
- Tully
- Lannercost
- Lillypond
- Mackay
- Bundaberg
<table>
<thead>
<tr>
<th>Site</th>
<th>Soil Type</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
<th>pH_\text{water}</th>
<th>TOC mg/g</th>
<th>TN mg/g</th>
<th>ECEC cmol/kg</th>
<th>MAP mm/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bundaberg</td>
<td>Ferrosol</td>
<td>17.3</td>
<td>23.1</td>
<td>59.6</td>
<td>6.73</td>
<td>18.6</td>
<td>1.9</td>
<td>9.9</td>
<td>1027</td>
</tr>
<tr>
<td>Mackay</td>
<td>Chromosol</td>
<td>43.7</td>
<td>32.5</td>
<td>23.8</td>
<td>6.47</td>
<td>14.0</td>
<td>1.3</td>
<td>7.6</td>
<td>1697</td>
</tr>
<tr>
<td>Lilypond</td>
<td>Dermosol</td>
<td>44.6</td>
<td>28.1</td>
<td>27.3</td>
<td>5.85</td>
<td>15.4</td>
<td>1.2</td>
<td>9.4</td>
<td>2211</td>
</tr>
<tr>
<td>Lannercost</td>
<td>Vertosol</td>
<td>37.0</td>
<td>34.6</td>
<td>28.4</td>
<td>4.94</td>
<td>11.8</td>
<td>1.1</td>
<td>4.4</td>
<td>2472</td>
</tr>
<tr>
<td>Tully</td>
<td>Hydrosol</td>
<td>49.6</td>
<td>21.1</td>
<td>29.3</td>
<td>5.18</td>
<td>18.6</td>
<td>1.3</td>
<td>4.1</td>
<td>4090</td>
</tr>
<tr>
<td>Innisfail</td>
<td>Kandosol</td>
<td>52.2</td>
<td>17.0</td>
<td>30.8</td>
<td>5.17</td>
<td>28.5</td>
<td>1.7</td>
<td>4.0</td>
<td>3550</td>
</tr>
</tbody>
</table>
## Treatments

1. U: urea;

2. NI+U: nitrification inhibitor-coated urea;

3. 25% PCU: 25% polymer-coated urea + 75% U;

4. 6ES: fertiliser N application rate based on the Six Easy Steps (6ES) nutrient management guidelines.

<table>
<thead>
<tr>
<th>Treatment #</th>
<th>Fertiliser types/ratios</th>
<th>N application rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>U&lt;sup&gt;1&lt;/sup&gt;</td>
<td>75% 6ES&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>U</td>
<td>6ES</td>
</tr>
<tr>
<td>4</td>
<td>U</td>
<td>125% 6ES</td>
</tr>
<tr>
<td>5</td>
<td>NI+U&lt;sup&gt;2&lt;/sup&gt;</td>
<td>6ES</td>
</tr>
<tr>
<td>6</td>
<td>NI+U</td>
<td>75% 6ES</td>
</tr>
<tr>
<td>7</td>
<td>25% PCU&lt;sup&gt;3&lt;/sup&gt;</td>
<td>6ES</td>
</tr>
<tr>
<td>8</td>
<td>50% PCU</td>
<td>6ES</td>
</tr>
<tr>
<td>9</td>
<td>75% PCU</td>
<td>6ES</td>
</tr>
<tr>
<td>10</td>
<td>25% PCU</td>
<td>75% 6ES</td>
</tr>
<tr>
<td>11</td>
<td>50% PCU</td>
<td>75% 6ES</td>
</tr>
<tr>
<td>12</td>
<td>75% PCU</td>
<td>75% 6ES</td>
</tr>
</tbody>
</table>

- U: urea;
- NI+U: nitrification inhibitor-coated urea;
- PCU: polymer-coated urea;
- 6ES: fertiliser N application rate based on the Six Easy Steps (6ES) nutrient management guidelines.
PCU mesh bag field incubation

- Buried at ~ 10 cm below the soil surface;
- Sampled fortnightly, monthly, then bimonthly
- N release estimated from weight loss (calibrated against N loss)
N release dynamics of different PCU products
N release dynamics of different PCU products (mean of all sites)
Effectiveness of nitrification inhibitor (DMPP) (0 – 20 cm soil)

• The Bundaberg soil had strong nitrification; NI more effective..

• NI can be effective for 1.0 - 1.5 months.

• The Lilypond soil had weaker nitrification; NI less beneficial.
Dynamics of soil mineral N (0-20cm)

- Soil mineral N in the U or NICU treatments mostly disappeared by mid-cropping season.

- PCU treatments maintained high mineral N level in mid- to late season
Movement of nitrate N (NO$_3^-$-N) to deep soil

Bundaberg

Lannercost

Days after fertiliser application (DAF)
Aboveground crop N uptake and sugar yields
Bundaberg (2018-19)
Aboveground crop N uptake and sugar yields
Lannercost, Ingham (2018-19)
Possible reasons for lack of responses to EEFs

- Sufficient N supply from soil (N not limiting)
  - High N mineralisation from SOM & cane trash
  - Sufficient N supply from fallow legume crop residues
  - Residual fertiliser N from previous crop

- Other limiting factors (nutrients, physico-chemical constraints)

- Adverse weather conditions (drought, water logging, lodging etc.)
Possible reasons for lack of responses to EEFs

- Excessive fertiliser N use
- Low risk of N loss
- Inappropriate management practices (timing, placement, pests)
- Modest N demand during the mid- to late season
- Spatial variability
Summary

- NI (DMPP) can slow down nitrification for up to 1.5 months;
- Duration of N supply: PCU > U and U+NI;
- N release dynamics from PCU varied little between different sites;
- Better synchronisation between PCU N release and crop N uptake;
- N leaching risk: U ≥ U+NI > PCU;
- N₂O emissions: U+NI < U ≤ > PSCU;
- EEF efficacy for yield improvement depends on site & weather conditions.
Communication and extension to industry (2019-20)

- Sugarcane field day, Tully.
  - Ayr;
  - Ingham;
  - Tully;
  - Cairns;
  - Mackay;
  - Bundaberg.
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- ICL Specialty Fertilisers
- Incitec Pivot Ltd.
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