Nitrogen:
continuing perspectives in
time and space!

Bernard Schroeder

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Glen Park, Eric Kok, Zofia Ostatek-Boczynski, Gavin Rodman,
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Australian Sugar industry

- 2000 km: from Mossman to Grafton.
- 30 – 36 Mt sugarcane and 4 – 4.5 Mt sugar per annum from 380,000 ha.
- Contributes about $A$2 billion annually to the Australian economy.
- Range of soil types (sands to heavy clays, acidic to alkaline, low to high CECs, low to relatively high org C contents, etc.).
- Various landscapes and several climatic zones.
- Much of the Queensland industry is located adjacent to the GBR.
Sustainable sugarcane production

• Important for Australian sugarcane production to be profitable and environmentally responsible.

• Best management practices (BMPs) need to be:
  • Practical,
  • Cost-effective,
  • Aim to maintain on-farm resources, and
  • Reduce the risk of losses of agricultural inputs.
“SIX EASY STEPS”

- A comprehensive, integrated and science-based nutrient management program.
- Recognised as the basis for developing, promoting and adopting nutrient BMPs in sugarcane production.
- It promotes balanced nutrition encompassing all essential nutrients.
- Recognises the range of districts, soil types and soil properties.
- Aims to optimise conditions for effective, economic and efficient use of nutrients (supplied in soil and those added by fertiliser and ameliorant applications).
“SIX EASY STEPS”

Stage of SIX EASY STEPS development

1. Undertake general assessment.
2. Identify major soils types.
3. Establish soil reference sites.
4. Consider/review existing information.
5. Conduct investigations.
6. Infer nutrient management strategies.
7. Develop ‘tools’ to support strategies.
8. Validate nutrient management strategies.
9. Present nutrient management package to users.
10. Demonstrate advantages to stakeholders.
11. Identify innovative approaches to enhance the system.

<table>
<thead>
<tr>
<th>Wet Tropics and Herbert districts: DYP = 120 t cane/ha</th>
<th>Soil organic C (%)</th>
<th>0.0</th>
<th>0.4</th>
<th>0.8</th>
<th>1.2</th>
<th>1.6</th>
<th>2.0</th>
<th>&gt;2.4</th>
</tr>
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<tbody>
<tr>
<td>N mineralisation index</td>
<td>VL</td>
<td>L</td>
<td>ML</td>
<td>M</td>
<td>MH</td>
<td>H</td>
<td>VH</td>
<td></td>
</tr>
<tr>
<td>CROP</td>
<td>Base N application rate</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Replant and ratoons after plant and replant cane</td>
<td>160</td>
<td>150</td>
<td>140</td>
<td>130</td>
<td>120</td>
<td>110</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Plant cane after a grass/bare fallow</td>
<td>140</td>
<td>130</td>
<td>120</td>
<td>110</td>
<td>100</td>
<td>90</td>
<td>80</td>
<td></td>
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Here we report on:

- Continuing perspectives of N management in sugarcane.
- Developments that have implications for STEPS 5 and 6 of the SIX EASY STEPS program.
- Results of recent investigations.
- Strategies going forward.
## General improvements

### Short-courses/workshops

<table>
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<tr>
<th>Course/Workshop</th>
<th>Target Audience</th>
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<td>CRC Sugar ‘train-the-trainer’ short course presented to ± 120 industry</td>
<td>± 120 industry advisors/stakeholders (late 1990s and early 2000s).</td>
</tr>
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<td>Grower and advisor-orientated short-course “An integrated approach to</td>
<td>Present to more than 1800 growers, advisors and</td>
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<td>sustainable nutrient management for sugarcane”</td>
<td>industry stakeholders.</td>
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<tr>
<td>District-specific SIX EASY STEPS nutrient management workshops and SIX</td>
<td>Present to more than 1800 growers, advisors and</td>
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<td>EASY STEPS workshop manuals (mid 2000s – present).</td>
<td>industry stakeholders.</td>
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### Decision-support applications

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<td>Simple semi-automated EXCEL-based spreadsheet</td>
<td>To determine nutrient inputs from lookup tables.</td>
</tr>
<tr>
<td>SIX EASY STEPS NutriCalc™ geographically-referenced on-line nutrient</td>
<td>To improve nutrient management on-farm.</td>
</tr>
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<td>management package (SRA/USQ) accessible since 2011 (SRA website).</td>
<td></td>
</tr>
<tr>
<td>SRA FertFinder</td>
<td>Enables determination of the best combination of products to supply nutrient</td>
</tr>
<tr>
<td></td>
<td>requirements per block (SRA website).</td>
</tr>
</tbody>
</table>
### General improvements

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<tr>
<th>Nutrient management planning</th>
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<tr>
<td>Nutrient management planning has always been included in the SIX EASY STEPS workshops as a practical exercise and illustrative purposes.</td>
</tr>
<tr>
<td>WTSIP-initiated five (5) -stage NMP process to assist growers to formulate rationalised whole-of-farm fertiliser requirements for their farms (Skocaj <em>et al.</em>, 2018).</td>
</tr>
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![Ratoon Fertiliser Shopping List](image)
Progress beyond STEP 4

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STEPS 5 & 6 enable expansion of the system to include a range of options for further fine-tuning of N management. This includes refinements:

• For specific circumstances.
• As new information becomes available.
• To meet an individual grower’s needs and/or appetite for risk.
SIX EASY STEPS: STEPS 5 and 6

• Content of the SIX EASY STEPS program in itself continues to undergo review, updating and refreshing.
• Options, outcomes and outputs from various projects and systems are possible within STEPS 5 and 6.
• Some of the options will align with the SIX EASY STEPS program.
• Other options may be considered too far from the intent of the SIX EASY STEPS and then would be separate approaches.
• Researchers and development specialists are responsible for the systems and outputs they develop.
• Growers, extension providers and advisors need to have confidence in, and take responsibility for, the system they choose, use and/or promote.
• Despite an emphasis on N, other nutrients are equally important.
SIX EASY STEPS TOOLBOX

• A ‘repository’ of all information and ‘tools’ that are part of, or support, the SIX EASY STEPS program.
• Options, outcomes and outputs from various sources that are compatible with the SIX EASY STEPS program, especially relating to STEPS 5 and 6.
What’s in the “BOX”?

NutriCalc™
Search SRA Website - request username and password

Template for nutrient management plans
A five stage process:
1. Knowing and understanding the soils on-farm.
2. Grower profile
3. Identify nutrient requirements and draft fertiliser plan
4. Finalise NMP
5. Review and update NMP

FertFinder
Search SRA Website – Download and start using
SIX EASY STEPS N guidelines

- Recognise:
  - Different **districts**.
  - Different **soils within those districts**.
- Use the following “suite of concepts”:
  - District yield potential (**DYP**).
  - **Multiplier**: 1.4 kg N/tc up to 100 tc/ha and 1.0 kg N/tc thereafter.
  - Soil N mineralisation index for determining discounts.
- Calibrated against response curves from past/present field trials.

\[
N \text{ rate (kg N/ha)} = \left[ \text{“Yield term” (tc/ha)} \times \text{multiplier (kg N/tc)} \right] - \text{N discount}
\]

- Response curves
- District yield potential (**DYP**)
- CSIRO bench mark
- N mineralisation index
Projects that could contribute potential tools for the SIX EASY STEPS TOOLBOX

- 2014/045 Boosting NUE in sugarcane through temporal and spatial management options (Schroeder et al.).
- 2014/011 Role of CR fertilisers in sugarcane systems (Verburg et al.).
- 2015/065 Improving NUE for sugarcane with constrained yield potential (Skocaj et al.).
- 2015/075 How much N does that crop need? (Everingham et al.).
- 2015/069 Soil N mineralisation tests and assessment of soil N contribution (Moody et al.).
- 2015/070 Spatially explicit estimation of Achievable Yield Potential (Bramley et al.).
- 2017/004 SIX EASY STEPS – continuing perspectives in time and space (Schroeder et al.).
- 2017/009 Unravelling the impacts of climate and harvest time on nitrogen fertiliser management (Skocaj et al.).
Other yield-related concepts

- DYP was developed as a **regional or district discriminator** and not meant to be substituted with an actual block yield value!
- BYP, PUYP and MUYP, and spatial patterns of yield (Herbert district) have been suggested by others as alternatives to DYP.
- Long-term N trials (Herbert, Tully, Bundaberg, Mackay) do not show a direct relationship between N rate and crop yield.

Optimum N rates (corresponding to 95% of the highest attained yield) remain relatively stable despite yield fluctuations caused primarily by seasonal climatic conditions.
Other yield-related concepts

- Generally stable spatial yield patterns (Bramley et al., 2017):
  - Valuable in identifying productivity zones within districts.
  - Useful for determining relationships to the distribution of soils.
  - Would need nutrient response experiments to be conducted across soils types within the full range of productivity groups.
  - Could be used by growers within productivity zones to consider adjustments away from the SIX EASY STEPS N guidelines as part of STEPS 5 and 6 (on-farm validation would be required).

- Maps from harvest yield monitors (Bramley and Jensen, 2013) and remoted sensing such as NDVI (Robson et al., 2015):
  - Provides images of yield and crop variability across blocks and farms.
  - Not yet a sound basis for determining required nutrient rates.

- Digital soil mapping (e.g. EC-generated maps):
  - Increasing use for selecting soil sampling points within blocks.
  - Still being investigated for determining nutrient requirements (Robson et al., 2015).
Can the concept of NUE be included in the SIX EASY STEPS Toolbox?

- Defined in different ways
- Simple terms: \( \text{NUE} = \frac{\text{outputs}}{\text{inputs}} \)
- Fertiliser N-use efficiency
  - Most common
  - Easy to calculate and understand
- **Fertiliser NUE** \( (\text{t cane/kg N}) = \)
- **Cane Yield** \( (\text{t cane/ha}) / \text{N fertilizer applied (kg N/ha}) \)
- Expressed at different scales: Within block, block or farm.
### NUE: Grower data

<table>
<thead>
<tr>
<th>Year</th>
<th>CROP CLASS</th>
<th>TCH (t cane/ha)</th>
<th>N RATE (kg N/ha)</th>
<th>NUE (t cane/kg N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-08</td>
<td>1R</td>
<td>132</td>
<td>140</td>
<td>0.94</td>
</tr>
<tr>
<td>2008-09</td>
<td>2R</td>
<td>96</td>
<td>140</td>
<td>0.69</td>
</tr>
<tr>
<td>2009-10</td>
<td>3R</td>
<td>107</td>
<td>140</td>
<td>0.76</td>
</tr>
</tbody>
</table>

- Tully series soil
- Organic carbon 0.89%, Ratoon N rate requirement 140 kg N/ha
Yield and NUE: trial data

- A target NUE cannot be used to determine N application rate.
- Use NUE to understand why yields are possibly lower than they should be due to some factor other than N management.
Multi-facetted analyses

- Poggio et al., 2016: Evaluation of practice change is better undertaken when agronomic, social economic and environmental consequences are considered.

\[ y = -0.0012x^2 + 0.5065x + 60.039 \]

- Partial net return (120 kg N/ha) = $4586/ha
- Partial net return (150 kg N/ha) = $4799/ha
- Partial net return (180 kg N/ha) = $4913/ha
Can temporal N management options contribute to the SIX EASY STEPS Toolbox?

1. Split applications
2. Use of Enhanced Efficiency Fertilisers (EEFs)
   a) Slow release fertilisers
   b) Controlled release fertilisers (CRFs)
   c) Inhibitors (urease inhibitors / nitrification inhibitors.)
EEFs – different formulations

- Reports of maintained yields/reduced N losses when EEFs used at lower N rates (Wang et al., 2012; 2014).
- Improved NUE when EEFs are used (Verburg et al., 2016)
- However, EEFs appear to be more effective in some situations than others, and they are more expensive than straight urea.

- Clay: Herbert (First ratoon)

- Supplier of DMPP-coated urea: a decision support tree to guide usage.
- Large adoption-focused project has been initiated from Bundaberg northward (Anon., 2017).
Can seasonal climate-forecasting help guide N rates?

El Nino Southern Oscillation (ENSO)

- Major influence on climatic conditions in many sugarcane areas

- Two phases:
  - **La Nina**
    - Cooler SST East
    - Positive SOI (+10)
    - Strong trade winds
    - High pressure East
  - **El Nino**
    - Warmer SST East
    - Negative SOI (-10)
    - Trade winds weaken
    - High pressure West

Skocaj: PhD thesis
Development of an N App

Climate forecasting, soil properties, N response curves and risk as a basis for suggesting alternative N rates.

Y Everingham, P Thorburn, D Skocaj, J Biggs, J Sexton, B Schroeder
‘Tools’ from the CANEGROWERS/ Qld Gov Smartcane BMP Roadmap initiative

Intent: better alignment of N inputs to crop requirements:

• Legume fallow crops
• Late harvest
• Ratoon age
• Water-logging
• Season
• Yields constrained by adverse conditions (e.g. sodic soils)

Working group (Quirk and others)
What’s in and what’s out?

Proposed the formation of a SIX EASY STEPS ADVISORY COMMITTEE (SESAC)

- A mechanism for assessing additions/modifications to the content of the SIX EASY STEPS program and linkages to the SIX EASY STEPS principles was included in a FRP (BS013).
- The envisaged SESAC will consider developments in a process similar to the review process used for journal papers.
- The SRA Funding Unit has indicated that the SESAC will operate and be funded separately to individual projects.
SESAC: proposed terms of reference

- Representation that includes various stakeholder interests (independent chairperson, 3 representatives from the SIX EASY STEPS team, 3-4 members from outside the SIX EASY STEPS team inclusive of stakeholder groups).
- The SESAC will set standards for accepting modifications and/or additions to the SIX EASY STEPS guidelines and delivery packages/tools.
- The Chair will co-ordinate the activities of the SESAC, receive submissions and ensure that the information is refereed and processed in a timely manner. Decisions will be by consensus.
- The SIX EASY STEPS team will incorporate accepted data / information / tools, etc into the SIX EASY STEPS program / TOOLBOX as appropriate.
- SRA has agreed to this and will fund its operation for the next few years.
Conclusions

• The SIX EASY STEPS program is evolving and maturing with time.

• The current ‘tools’ in the SIX EASY STEPS TOOLBOX provide a sound basis for adoption of nutrient BMP up to and including STEP 4 of the program.

• Recognition as the BMP standard means that the SIX EASY STEPS program provides a mechanism for continuous improvement and cyclical learning especially in terms of STEPS 5 and 6.

• The proposed SESAC will ensure that meaningful/scientifically sound additions are made to the program and SIX EASY STEPS TOOLBOX.

• This will also ensure that stakeholders have confidence in the SIX EASY STEPS ‘tools’ they choose, use and/or promote for specific on-farm circumstances.

• The SIX EASY STEPS program continues to have a balanced approach that considers the agronomic, economic, social and environmental aspects of nutrient management.