

Nitrogen: continuing perspectives in time and space!

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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.

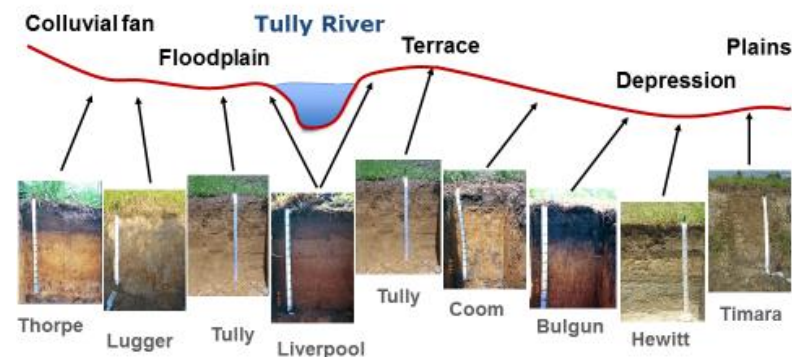
“SIX EASY STEPS”

- 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 .



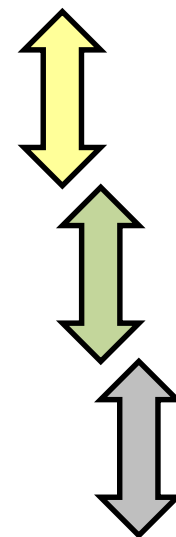
Wet Tropics and Herbert districts: DYP = 120 t cane/ha)

Soil organic C (%)	0.0 – 0.4	0.4 – 0.8	0.8 – 1.2	1.2 – 1.6	1.6 – 2.0	2.0 – 2.4	>2.4
N mineralisation index	VL	L	ML	M	MH	H	VH

CROP	Base N application rate						
Replant and ratoons after plant and replant cane	160	150	140	130	120	110	100
Plant cane after a grass/bare fallow	140	130	120	110	100	90	80

“SIX EASY STEPS”

Logical steps within the SIX EASY STEPS program	
STEP	Description
1	Knowing and understanding our soils.
2	Understanding and managing nutrient processes and losses.
3	Soil testing regularly.
4	Adopting soil-specific nutrient management guidelines.
5	Checking on the adequacy of nutrient inputs.
6	Interpreting trends and modifying inputs when/where necessary.



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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

	CRC Sugar ‘train-the-trainer’ short course presented to ± 120 industry advisors/stakeholders (late 1990s and early 2000s).	Presented to more than 1800 growers, advisors and industry stakeholders.
	Grower and advisor-orientated short-course “An integrated approach to sustainable nutrient management for sugarcane”.	
	District-specific SIX EASY STEPS nutrient management workshops and SIX EASY STEPS workshop manuals (mid 2000s – present).	

Decision-support applications

	Simple semi-automated EXCEL-based spreadsheet to determine nutrient inputs from lookup tables.	Tools to improve nutrient management on-farm.
	SIX EASY STEPS NutriCalc™ geographically-referenced on-line nutrient management package (SRA/USQ) accessible since 2011 (SRA website).	
	SRA FertFinder enables determination of the best combination of products to supply nutrient requirements per block (SRA website).	

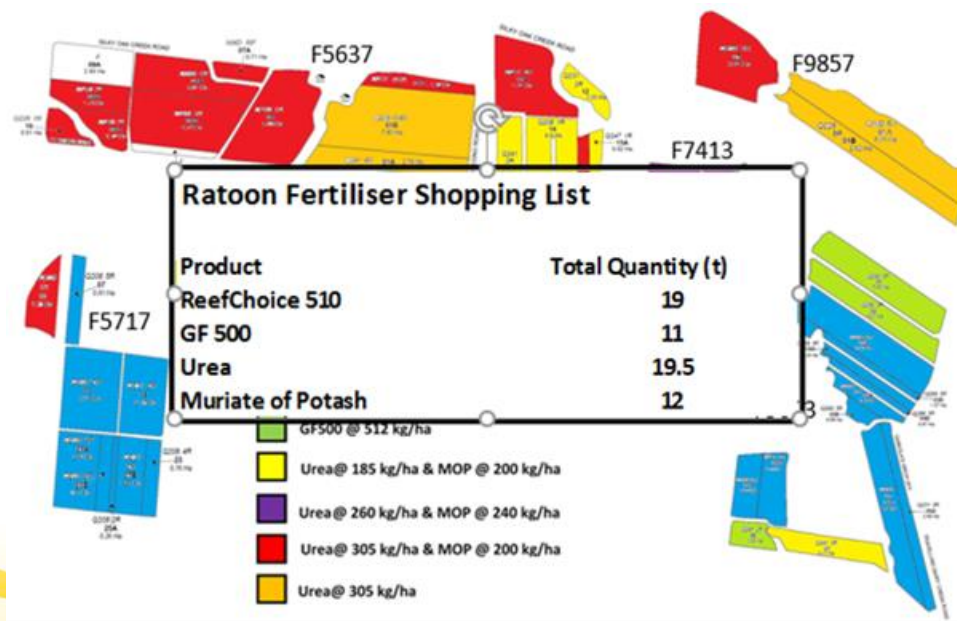
General improvements

Nutrient management planning

Nutrient management planning has always been included in the SIX EASY STEPS workshops as a practical exercise and illustrative purposes.

WTSIP-initiated five (5) -stage NMP process to assist growers to formulate rationalised whole-of-farm fertiliser requirements for their farms (Skocaj *et al.*, 2018).

Helping growers to
develop their own
nutrient
management plans.



Progress beyond STEP 4

Logical steps within the SIX EASY STEPS program	
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6	Interpreting trends and modifying inputs when/where necessary.

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.



SIX EASY STEPS

Shutterstock (accessed 2018)



What's inside?

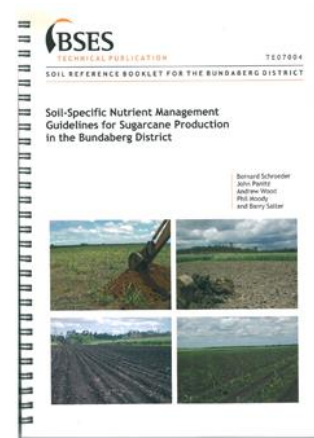
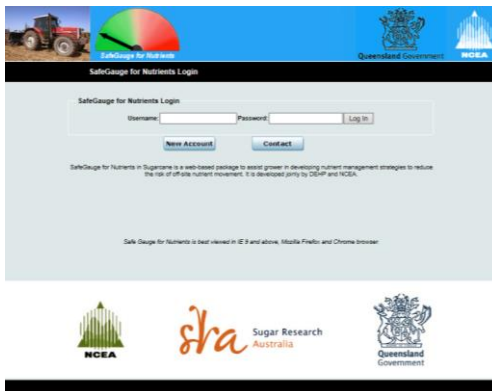
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What's in the "BOX"?

NUTRIENT MANAGEMENT GUIDELINES FOR SUGARCANE IN THE WET TROPICS

sha Sugar Research Australia

Table with 10 columns: Nutrient, Soil Type, Application Rate (kg/ha), and other parameters. Rows include Nitrogen, Phosphorus, Potassium, and Sulfur for various soil types.



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



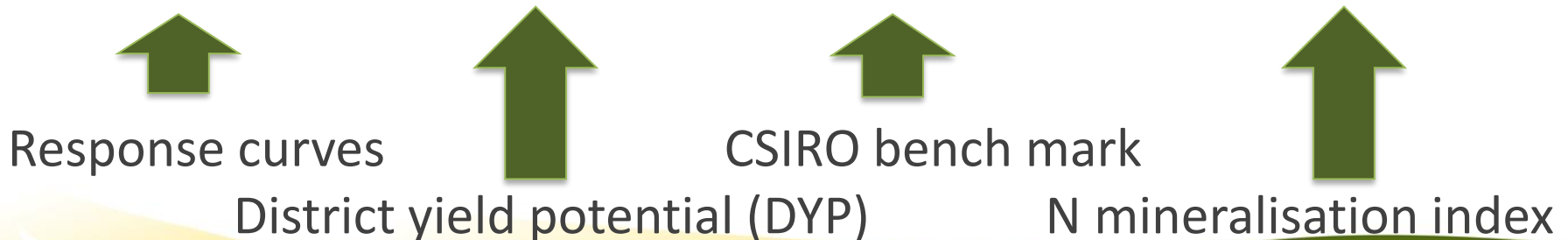
G. Rodman

J Panitz, L Agustina, B Schroeder

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 rate (kg N/ha) = [“Yield term” (tc/ha) x multiplier (kg N/tc)] – N discount

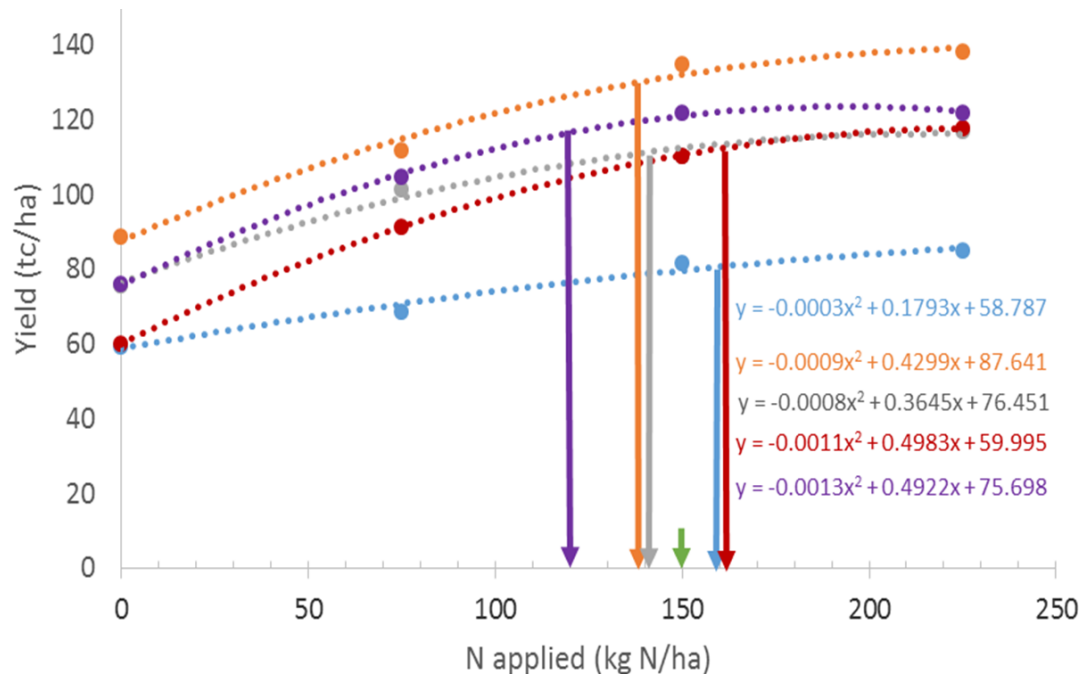


Projects that could contribute potential tools for the SIX EASY STEPS TOOLBOX

- 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.



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?

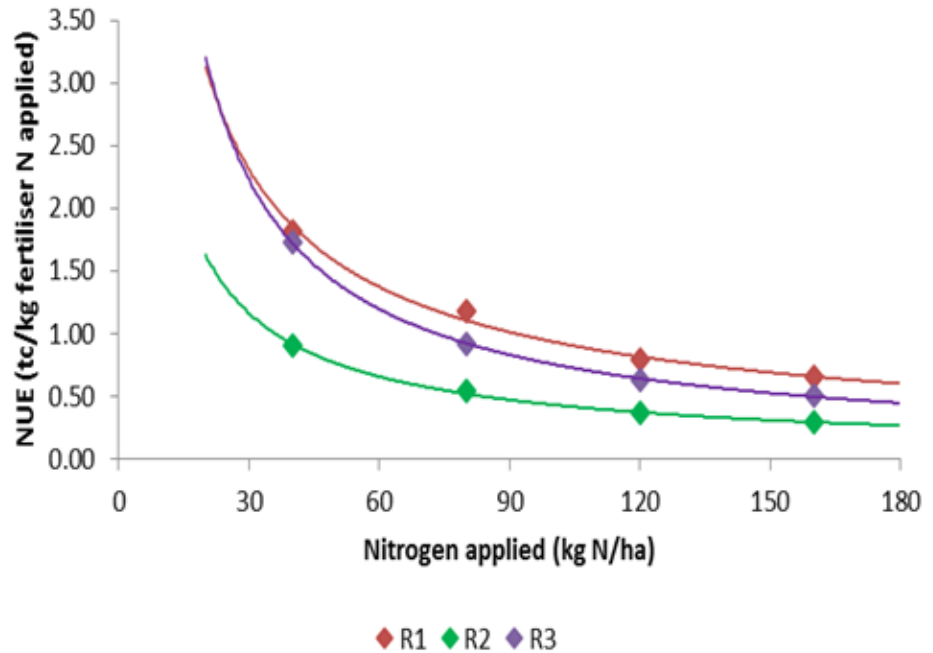
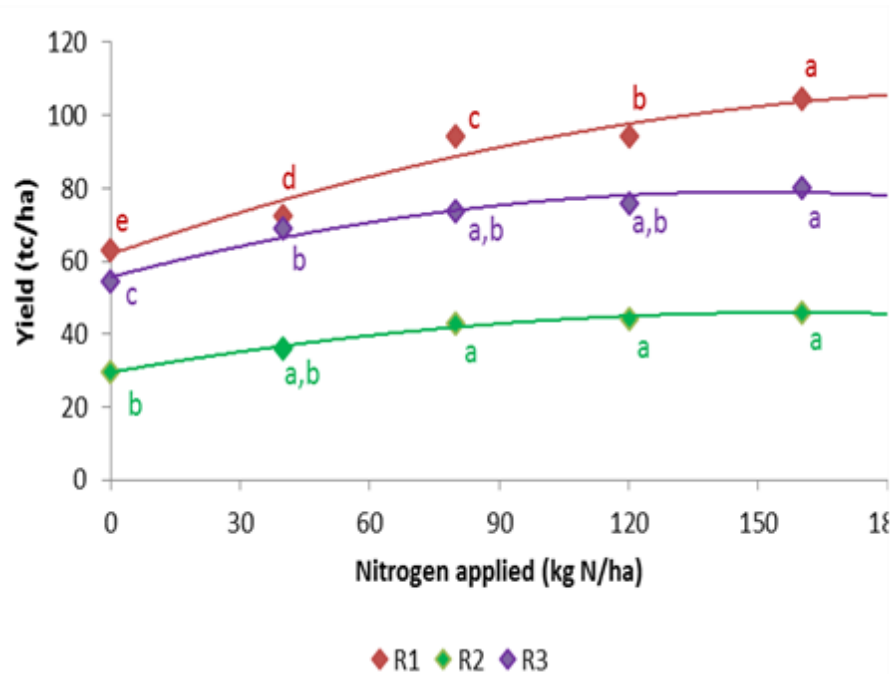
- Defined in different ways
- Simple terms: $\text{NUE} = \text{outputs} / \text{inputs}$
- Fertiliser N-use efficiency
 - Most common
 - Easy to calculate and understand
- **Fertiliser NUE** (t cane/kg N) =
- **Cane Yield** (t cane/ha)/**N fertilizer applied** (kg N/ha)
- Expressed at different scales: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

NUE: Grower data

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

- Tully series soil
- Organic carbon 0.89%, Ratoon N rate requirement 140 kg N/ha

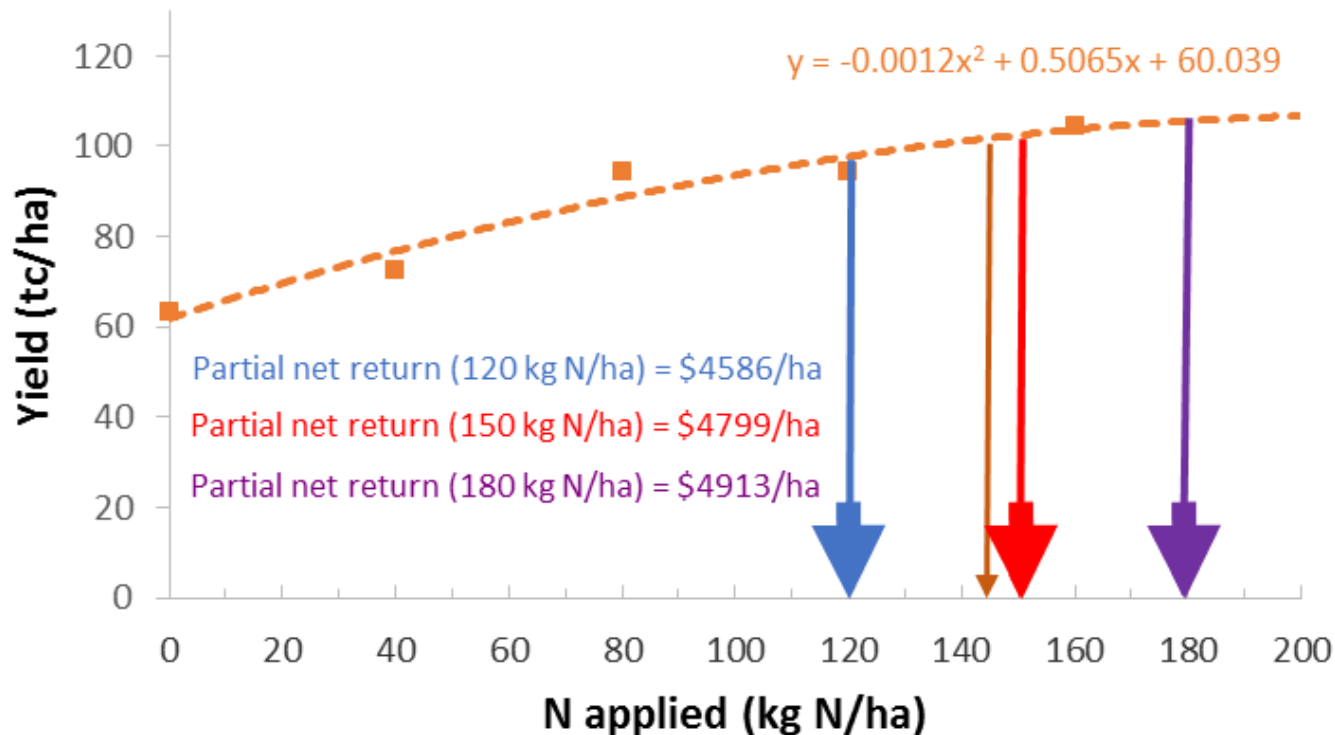
Yield and NUE: trial data



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

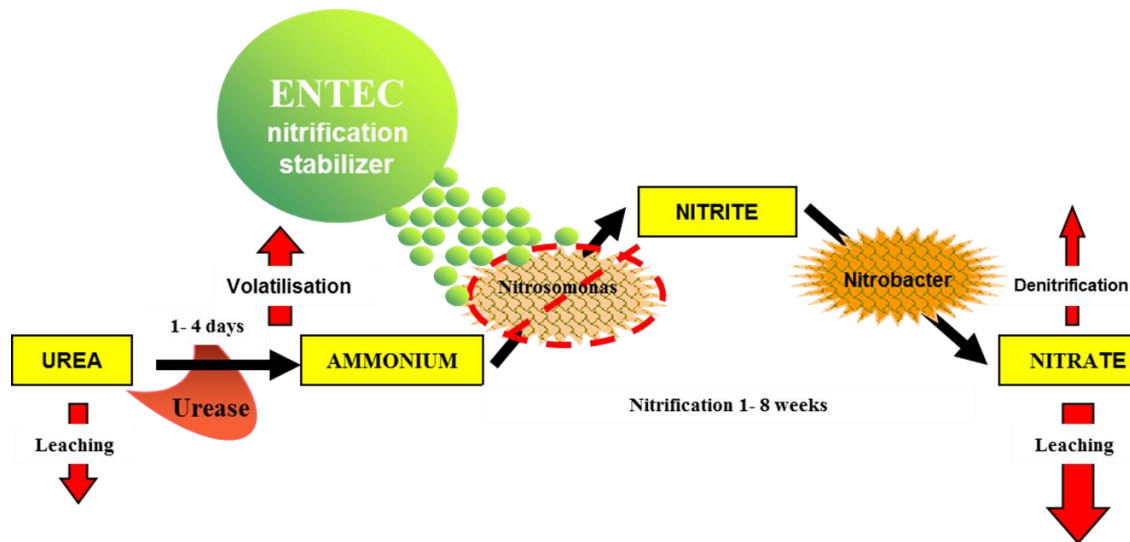
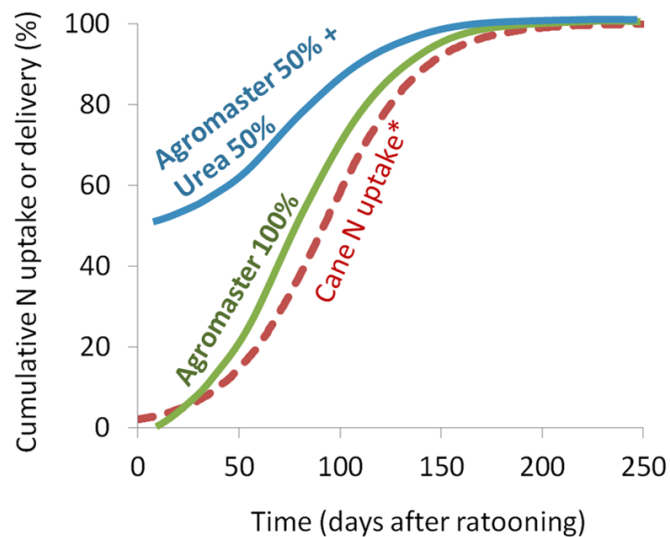
Multi-faceted analyses

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



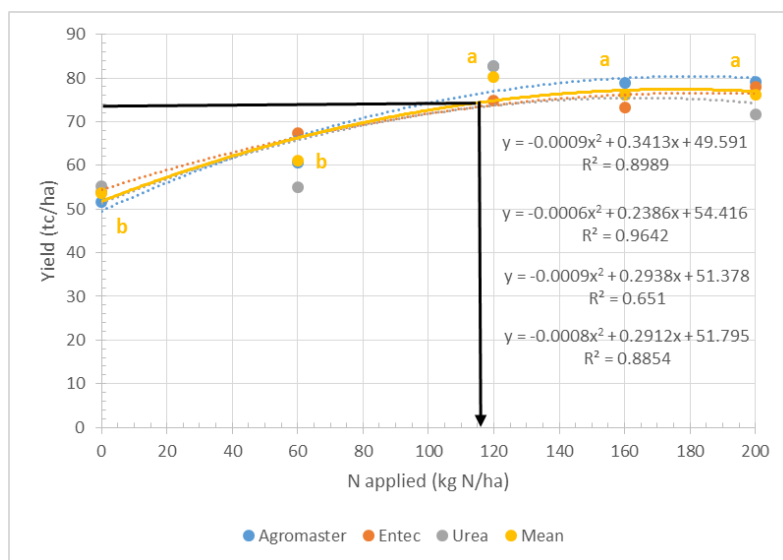
Can temporal N management options contribute to the SIX EASY STEPS Toolbox?

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.



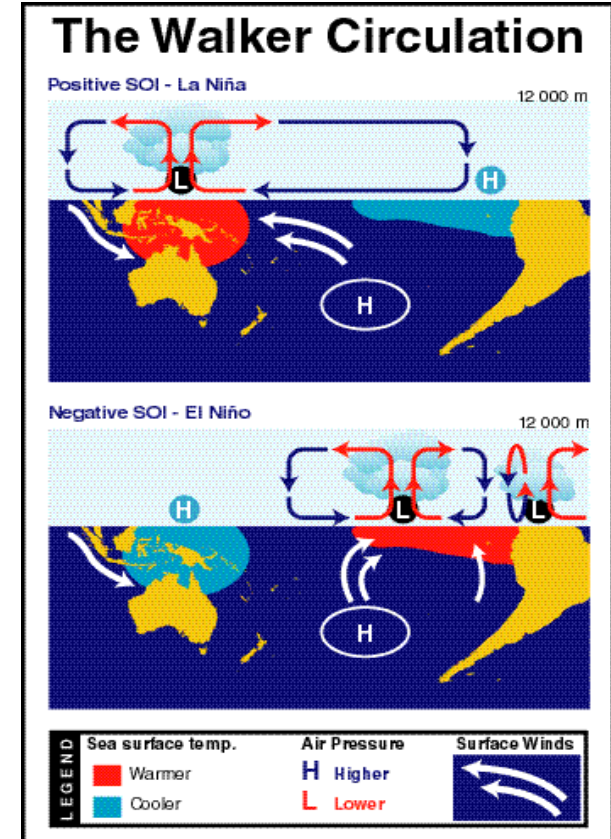
Clay: Herbert (First ratoon)

- 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)

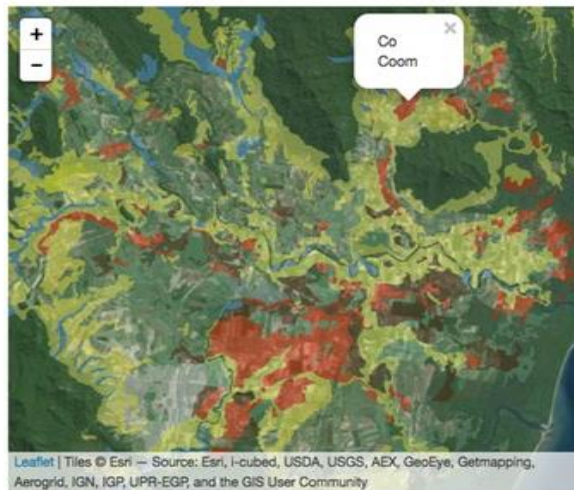
- Major influence on climatic conditions in many sugarcane areas
- Two phases:
 - **La Nina**
 - Cooler SST East
 - Positive SOI (+10)
 - Strong trade winds
 - High pressure East
 - **El Nino**
 - Warmer SST East
 - Negative SOI (-10)
 - Trade winds weaken
 - High pressure West



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.



Location:
North of river

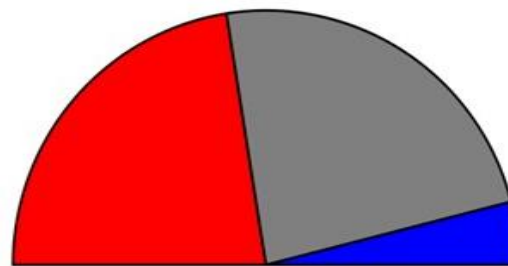
Approximate start of crop:
September

Range of N fertiliser rates
(kg/ha)

Low confidence 84 92

Medium confidence 92 98

High confidence 98 111



El Niño Neutral La Niña

'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)

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.