MORE PROFIT FROM

NITROGEN

Smart blending of Enhanced Efficiency Fertilisers to maximise sugarcane profitability — *An economic case study*

About the research

The More Profit from Nitrogen Program (MPfN Program) is a cross-sector partnership between Australia's four intensive agricultural users of Nitrogen (N) fertilisers, formed to undertake research into improving nitrogen use efficiency (NUE).

As part of the collaborative research, the Queensland Government Department of Environment and Science led a major research project across three growing seasons, conducting six replicated on-farm field trials in the major Queensland sugarcane growing regions of Innisfail, Tully, Ingham, Mackay and Bundaberg. This project aimed to investigate optimal blending ratios of Enhanced Efficiency Fertilisers (EEFs) with conventional Urea, under various soil and seasonal conditions.

Analysis of research — farm level economics of EEFs

A farm level framework was developed to evaluate the economic and environmental potential of optimising N application using EEFs to match N supply with plant nutrient demand. An analysis undertaken with data from two seasons at Lannercost, Ingham (Qld) used a partial budget model to compare total N applied at the Six-Easy-Steps rate (6ES) and the cost difference of N products, including Urea, Entec and a 75% PCU (41% N) + 25% Urea blend. Table 1 shows the responses of sugar yield and cost of N per tonne of sugar yield. Increases in sugar yield with EEFs were significant on only a few occasions at the six sites over the three-year project period. The cost of the PCU was double the cost of standard Urea at the same N application rate following 6ES[1].

KEY PROJECT RESULTS

- Sugar yields showed no consistent, statistically significant, differences between fertiliser N supplied by conventional Urea and EEFs, although the highest agronomic efficiency of all N fertiliser products was at the lowest N application rate.
- The use of Polymer Coated Urea (PCU) products can significantly reduce the risk of nitrate leaching during the first 2-3 months.
- Use of the project developed decision support tree can assist in pre-season fertiliser product/rate planning and aid in reducing N losses. The tool accounts for site characteristics, seasonal conditions and farm management practices.

Table 1 *— Sugar yield results and per hectare costs of three Urea products (Urea, Entec and PCU blend) over two seasons at Lannercost, Qld*

Product	Price ($/t)[a]	6ES rate (kg N/ha)	N Cost ($/ha)	Sugar Yield[b] (t/ha)	Change in yield	N Cost /t sugar/ha
Urea	500	145	$158	10.6	0 (base)	$14.9
Entec	620	145	$196	10.75	+1.4%	$18.23 (+22%)
PCU 75% Urea 25%	963	145	$331	11.2	+5.6%	$29.55 (+99%)

a. Reeves (personal communication, 2020)
b. Wang and Reeves, Project Technical Report (2020)

[1] *https://www.qld.gov.au/__data/assets/pdf_file/0032/67937/rwq-np-method.pdf*

Valuing economic and environmental losses from Urea fertiliser

Previous studies on EEF products found minimal consistent yield benefit or improvement in agronomic fertiliser NUE[2]. In this MPfN Program project, research found the unique release pattern of PCU minimised N loss in wet seasons, particularly where N fertiliser is applied immediately prior to heavy rainfall. If seasonal conditions, particularly rainfall, are confidently predicted, there is potential to provide greater accuracy in seasonal and annual EEF recommendations (formulation, rate and timing) and mitigate N loss via primary pathways. Therefore, to compare losses of generic EEF products with Urea, the value of N losses to the environment needs to be quantified.

Table 2 draws on industry research to overlay environmental costs associated with N loss to the environment using a 2% nitrous oxide (N_2O) emission factor[3] (EF) and two products applied at the 6ES rate for Lannercost (Qld). The latest market value from the Government Emission Reduction Fund reverse auction of $16/tonne CO_2e has been applied, together with a conversion factor of 298 kg CO_2e per kg N_2O. Studies by Wang et. al. (2012 & 2014)[4] suggest that Entec decreased N_2O losses by around 50% on average. Therefore, the total value of N losses to the environment through N_2O emission and nitrate leaching at the case study site was estimated to be $37.5/ha for Urea and $24.1/ha for Entec. Accounting for the higher price of Entec, a 36% saving in environmental costs was found.

Table 2 *— Valuing Urea products lost to the environment under normal conditions using 6ES at Lannercost, Qld.*

Product	Applied rate (145 kg N/ha)	Emissions[4] (kg N_2O-N/ha/yr)	CO_2e Emissions (kg/ha/yr)	Emissions cost[5] ($/ha)	Leaching losses[6] (kg N/ha)	Leaching cost ($/ha)	Total value of N losses ($/ha)
Urea	315	2.9	1358	21.7	14.5	15.8	37.5
Entec	315	1.45	679	10.9	9.8	13.2	24.1

Sensitivity testing of N_2O emission factors and deep drainage losses.

Sensitivity analysis, broadly defined, is the investigation of these potential changes and errors and their impacts on conclusions to be drawn from the model. Analysis was undertaken to test the sensitivity of N_2O emission factors and deep-drainage losses from a range of soils and climate scenarios. Under extremely wet scenarios, denitrification and leaching of fertiliser N is more likely to occur[7] and, therefore, EEF products are more competitive against Urea when environmental benefits are considered.

Production, and hence economic benefits, may not necessarily be realised in very wet scenarios depending on the crop's response to N (as dependent on N rate and crop growth potential - with the latter potentially negatively affected by low radiation and waterlogging). The results of sensitivity analysis in Table 3 show that when the N_2O emission factor is high, and quantities of N leaching exceeds 10% per hectare, environmental and economic costs of Urea are substantial. Using a base cost of $158 / ha for Urea at the 6ES rate, the losses under the different scenarios (1-5% EF and 10-20% leaching) provide an indication of future price-points for EEF products to match Urea. The economic cost of N lost to the environment through deep drainage is the percentage value of the fertiliser only. Methods are currently under development to incentivise practices that result in avoided nitrate leaching using the 'paddock to reef modelling' undertaken in Great Barrier Reef catchments[8]. When all environmental costs associated with N_2O emissions and N leaching are market-based, the true economic value of EFFs compared to Urea will be more easily defined.

[2] https://www.publish.csiro.au/sr/pdf/SR15314
[3] https://www.industry.gov.au/sites/default/files/2020-05/nga-national-inventory-report-2018-volume-1.pdf
[4] https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg3-chapter8-1.pdf
[5] http://www.cleanenergyregulator.gov.au/ERF/Auctions-results/march-2020
[6] https://www.cottoninfo.com.au/sites/default/files/documents/Irrigation%20and%20N%20tour%20booklet%20-%20FINAL.pdf
[7] https://www.sciencedirect.com/science/article/abs/pii/S0167880911002829
[8] https://www.reefcredit.org/approved-methodologies/

***Table 3:** Sensitivity test results of combined per hectare economic and environmental cost ($/ha) of N losses for Urea fertiliser (N_2O emissions vs deep soil nitrate losses) using rate assumptions from 6ES at Lannercost, Ingham (Qld).*

Deep soil nitrate losses %	Nitrous oxide emission factor (%)		
	1.0%	2.5%	5.0%
10%	$26.63	$42.92	$70.08
20%	$34.51	$50.80	$77.96
30%	$42.39	$58.68	$85.84
40%	$50.27	$66.56	$93.72

Potential value for EEFs in sugarcane systems using seasonal forecasts.

As demonstrated by the sensitivity analysis, under certain climatic conditions, the environmental and economic costs associated with per hectare N losses can be substantial. Using seasonal forecasting, simultaneously with nutrient budgets, can present opportunities to better match fertiliser N with plant demand, particularly in years of high precipitation.

While benefits may only be realised every two to three years, where there are strong climate signals, it is worthwhile considering access to improved weather forecasting that can deliver greater confidence on the timing, intensity and amounts of rainfall and solar radiation during different climate phases. The charts in Figure 1 show how various climate phases captured in a seasonal forecast from a dynamical model can help determine in-crop rainfall at Ingham. The outlook shows a high probability (60-65%) of *greater* than median rainfall (249 mm) for October to December period with "very high" past accuracy.

The decision support tree developed by this project provides guidance on selection of fertiliser products. In periods of higher-than-normal rainfall, such as La Niña years, the probability of a wet growing season and higher N losses increases. To the contrary, drier El Niño years result in a reduced probability of high rainfall events. The project has recommended that more research is required to better quantify the economic costs and benefits of applying EEFs at various locations using seasonal forecasts in cane growing regions.

KEY PROJECT RESULTS

While the research found sugarcane yields showed no consistent, statistically significant, difference between conventional Urea and EEFs, knowledge has increased with the following key findings:

- Soil mineral N contents declined to very low levels early in-season after the application of Urea following high rainfall events;
- PCU products consistently sustained higher mineral N contents in soil; however, the trials found that the PCU benefits are mainly about mitigating N losses from leaching rather than increased crop yield;
- The lack of yield benefit from EEFs is specific to the N rates used, which may sometimes be above the agronomic optimum N for the seasonal conditions; and
- Yield responses to EEFs were found to be significant in only a small portion of trial sites throughout the 3-year trial period. Potential exists to better understand profitability under a range of management scenarios, changes in yield and N lost to the environment.

[3] https://www.publish.csiro.au/sr/sr15314
[4] https://www.cottoninfo.com.au/sites/default/files/documents/Irrigation%20and%20N%20tour%20booklet%20-%20FINAL.pdf

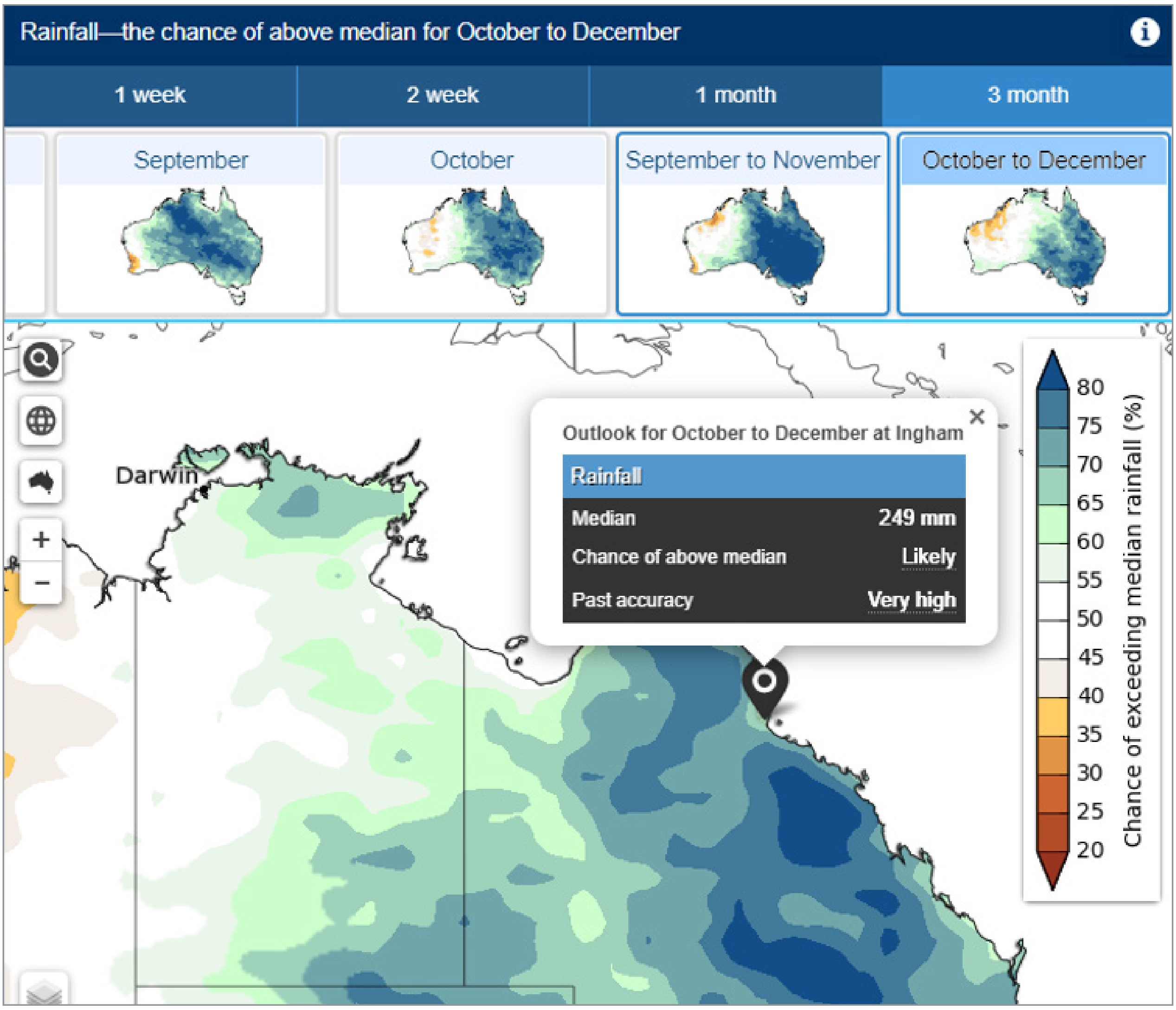

Figure 1. *— A seasonal forecast for spring 2021 produced by a dynamical model showing precipitation outlook (above or below median) for Ingham Qld http://www.bom.gov.au/climate/outlooks/#/rainfall/median/seasonal/1. Using EEF or blends in La Niña years, or where a high probability for wetter than normal conditions occur can offer benefits through avoided losses of fertiliser.*

MPfN

FURTHER INFORMATION

FOR FURTHER INFORMATION ON THE MPfN PROGRAM:

Smart blending of enhanced efficiency fertilisers to maximise sugarcane profitability **project, contact the project leader:**

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Visit www.crdc.com.au/more-profit-nitrogen

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