MORE PROFIT FROM NITROGEN

Accounting for mineralised nitrogen (N) in crop budgets to improve N use efficiency and profit — *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 N fertilisers, formed to undertake research into improving N use efficiency (NUE).

As part of the collaborative research, the NSW Department of Primary Industries (DPI NSW) led a major research project for the NSW sugarcane industry that generated greater knowledge and understanding of the interplay of factors to optimise N formulation, rate and timing for the NSW growing region. A major component of research was focused upon quantification of mineral N from soil and organic matter (Potentially Mineralisable N (PMN)), to determine whether industry best practice guideline application rates of N fertiliser could be adjusted by taking these sources into account when preparing a seasonal (300 days) crop N budget.

27 representative paddocks in northern NSW were sampled to determine the extent of subsoil (deep) N reserves to 1 metre. The samples were used to determine mineral N (i.e., plant available N) as well as PMN in the top 40cm soil layer using a range of tests assessing mineralisable N over 14-456 days. The results were used to inform mid-infrared reflectance (MIR)/near-infrared reflectance (NIR) algorithms that may allow PMN to be rapidly and inexpensively predicted in sugarcane soil.

Analysis of farm level economic benefits

A farm level framework, informed by the outcomes of the NSW based research, was developed to evaluate the economic and environmental potential of optimising N application in the central growing area of Queensland, a region that contains nearly a third of the industry's harvested hectares. The analysis assumed to apply the NSW research framework, methodology and calculation to evaluate the potential of using PMN testing to improve product budgeting and match N supply with plant nutrient demand under a regional scenario where mineralised soil N and soil carbon (C) is known to be lower than northern NSW soils. A partial budget model was used to compare total N applied using the sugarcane industry's Six-Easy-Steps (6ES) recommendations and the cost savings / emissions abatement from the additional N projections.

KEY PROJECT RESULTS

- Understanding the longer-term PMN of a soil may enable refinement of applied N additions to allow greater transparency of marginal returns of applied N and fertiliser response.
- The 14-day PMN can significantly underrepresent the soil supply of mineralisable N, as assays on soils that were conducted to 456 days show between a 2-5-fold increase in PMN across this time.
- MIR has provided a reasonable calibration to both 14-day and 300-day PMN, enabling an 'overnight' laboratory assessment of PMN. The MIR calibration is suitable for NSW sugarcane soils.
- Many sugarcane farms in NSW have significant stores of N in the soil, some up to 300 units, consisting of mineral N and PMN.
- There is an opportunity to refine the 6ES through soil testing for mineral N and PMN from the 0-40cm layer. This will provide greater accuracy of the potential soil supply of N for the crop and therefore refinement of the crop N fertiliser budget.

What is the PMN test and how is it derived?

N can be supplied to the crop through synthetic fertiliser and/or from existing stores of plant available nutrient in soil, as well as through PMN. The breakdown of organic material such as harvest residues (i.e. sugarcane trash), cover or break crops and soil organic matter releases plant available N to the crop, but the amounts supplied are currently difficult to incorporate into decision support tools, as predictive accurate measurements of organic N contribution have not been available.

PMN can vary greatly within soils and locations. When summing the mineral N over the cropping season was investigated, MPfN researchers found the PMN over 300 days ranged between 100-560 kg N/ha. Some of the soils are Hydrosols and have a high organic matter content. Analysis can be conducted with cores taken annually after harvest at a small additional cost.

Figure 1 illustrates the calculations used from a large field data set to predict PMN.

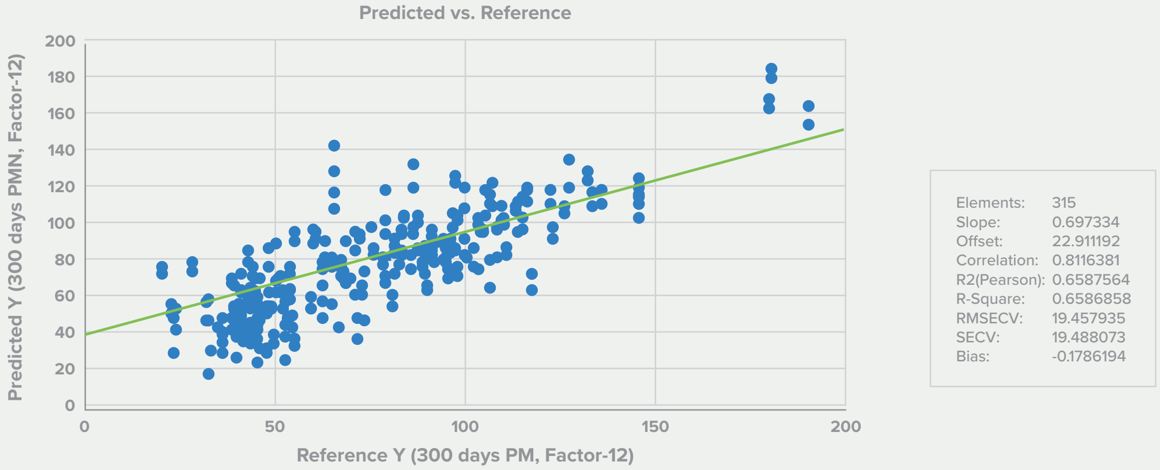

Figure 1. *— Correlation model developed for 14, 56 and 300-day PMN.*

Table 1 provides an example of a 40 hectare (ha) field at Mackay employing PMN analysis in nutrient budgets. Research findings suggest a "10% reduction" in per ha applied N rate under most circumstances. Assuming baseline 6ES guidelines for the location, an Emissions Factor (a coefficient which allows to convert activity data into GHG emissions) of 2% for irrigated sugarcane, and valuing emissions at $16 /t CO_2e, the combined environmental and economic impacts reveal an estimated $558 field-scale net benefit.

Table 1 *— Potential economic and environmental benefits of a 40 ha field at Mackay, employing PMN analysis in nutrient budgeting assuming a 10% reduction in N rate.*

40 ha field	Soil testing costs	Nitrogen rate (plant and ratoon crops)	Difference (per field)	CO_2e abatement[1,2]	Total net benefit
6ES for a soil with < 0.4% org C (Walkley and Black)	$0	170 kg/ha	$0	0 kg	$0
Additional PMN test	-$70	153 kg/ha	+$558	4,053 kg	+$1,040

[1] *http://www.cleanenergyregulator.gov.au/ERF/Auctions-results/march-2020/*
[2] *https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg3-chapter8-1.pdf*

The parameter values and assumptions of any economic model are subject to change and error. 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 the results to individual changes in fertiliser rates when considering PMN calculations and flow-on effects on N lost to the environment.

Table 2 shows the economic sensitivity results for N (in the form of Urea) and reduction in N rate using the Mackay case study.

Static commercial cane sugar (CCS) and yield is assumed. PMN enables reduced applied N, bounded by maximum and minimum market N values over a 10-year reference period. For example, when the PMN is high, and applied N rate is 40% lower and the cost of urea is $0.82/kg, the new N budget will achieve an estimated economic benefit of $55.80/ha. Provided that N price and PMN values make a positive contribution to the overall N budget outlined in the 6ES, the practice change should remain economical.

Table 2: *Economic sensitivity results - Urea and reduced N rate from employing PMN calculations, $/ha economic impact at Mackay, Qld.*

Reduction in N rate %	Urea ($/kg)			
	Per ha	Per ha	Per ha	Per ha
	$0.51	**$0.82**	**$1.14**	**$1.45**
10%	$8.7	$13.9	$19.4	$24.7
20%	$17.3	$27.9	$38.8	$49.3
30%	$26.0	$41.8	$58.1	$74.0
40%	$34.7	$55.8	$77.5	$98.6

Table 3 shows the environmental sensitivity of results against business as usual when applying PMN testing that results in a reduced applied N rate using the Mackay case study.

Research found nitrous oxide emissions can grow exponentially under the right climatic conditions, hence 5% was used in the sensitivity test[3]. Similarly, in wet years, nitrate leaching through the profile can occur. A baseline of 10% and 20% was used, drawn from studies undertaken in broad acre irrigation[4].

The results demonstrated that by accounting for PMN in a crop nutrient budget, a reduced applied rate of N could result in up to 1t/ha CO_2e avoided emissions. Similarly, by avoiding nitrate deep-drainage losses, almost 14 kgN/ha can be saved and contribute to the crop N budget.

Table 3: *Environmental sensitivity results - value of avoided nitrous oxide emissions and nitrate leaching from using PMN in nutrient budgeting.*

Reduction in N rate %	Avoided emissions (CO_2e / ha) and nitrate leaching (kgN/ha)			
	Emissions Factor (kgN_2O/ha)		Nitrate leaching (kgN/ha)	
	2%	5%	10%	20%
10%	101.32	253.3	1.7	3.4
20%	202.64	506.6	3.4	6.8
30%	303.96	759.9	5.1	10.2
40%	405.28	1,013.21	6.8	13.6

[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


One metre soil core extractions were undertaken across 27 sugarcane fields of the northern NSW growing region.

Economic analysis demonstrated that by employing PMN techniques in preparation of crop N budgets, alongside the 6ES, a more accurate account of N stocks available to the crop over the full growing period can be employed. Consideration of PMN will improve utilisation of plant-available N, optimise fertiliser inputs and result in avoided losses of N to the environment.

Where using PMN analysis results in lower applied N, both economic and environmental benefits eventuate through:

- Lower input costs from lower applied N;
- Reduced nitrous oxide emissions; and
- Reduced deep drainage losses from nitrate leaching.

MPfN

FURTHER INFORMATION

FOR FURTHER INFORMATION ON THE MPfN PROGRAM:

Improved NUE through accounting for deep soil and mineralisable N supply, and deployment of EEFs to better match crop N demand **project, contact the project leader:**

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

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