Dairy Australia

ECONOMIC CASE STUDY ALLANSFORD (VICTORIA)

Improving dairy farm nitrogen use efficiency

USING SOIL MOISTURE MONITORING

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 University of Melbourne (UoM), supported by Dairy Australia, conducted trials to better understand the contribution of soil mineral N[1] to dairy pastures under dryland and irrigated conditions.

Small plot field experiments were conducted at a commercial dairy farm located at Allansford, South West Victoria. Soil moisture monitoring was used as one of the advanced technology tools. The research highlighted the potential to reduce N application in the first autumn grazing cycle with minimal impact on productivity.

Under dryland systems, following a dry summer, limited plant growth results in reduced N uptake and greater availability of residual soil N, giving rise to opportunities to reduce N fertiliser applications without impacting pasture growth. Conversely, a wet summer results in increased uptake of N over both the summer and the following autumn. Under these conditions, the grazing system should benefit from autumn N applications. In irrigated systems, management of summer irrigation can have similar effects.

Using soil moisture monitoring to seasonally optimise autumn N application generated a positive economic impact of an additional $29/ha/year.

KEY MESSAGES

Economically beneficial to adopt a seasonally modified N application approach based on seasonal conditions and local growth potential.

Soil moisture monitoring data supports a more strategic approach to N application.

Reduce or delay autumn N applications after a dry or intermediate summer.

Increase N applications following a wet summer.

Analysis of farm level economic benefits

Drawing on the MPfN Program research, a farm level framework was developed to evaluate the economic implications of conducting soil moisture monitoring to optimise autumn N fertiliser applications at the Allansford trial site. The framework was based on the principle of profit maximisation, given the decreasing marginal returns from N application. The framework incorporated discounted cashflows to compare all costs and benefits.

The analysis used three years of MPfN Program trial data from the Allansford site, which identified the autumn pasture response to applied N following three different summers: dry, intermediate, and wet. For each of the three years, the analysis identified optimal N strategies to maximise the economic return for the first autumn grazing cycle. Table 1 shows the seasonally modified N application strategy compared to a typical practice fixed rate[2] strategy for the region, for the three different years of autumn grazing cycles. Table 2 shows the resultant change in dry matter (DM) production.

1 In the soil, mineral nitrogen is formed through the process of mineralisation whereby organic N is converted to plant-available inorganic forms.

2 Typical autumn N application rates for the Allansford trial site were identified by the researchers as a fixed rate of 40 kg N/ha/cycle.

Table 1 Comparison of fixed rate (FR) and seasonally modified (SM) N application for the first autumn grazing cycle.

Trial year and preceding summer	FR N (kg/ha/cycle)[2]	SM rate N (kg/ha/cycle)	Change in N (kg/ha/cycle)	$/t urea[3]	Change in cost of N ($/ha)
2016-17 (dry)	40	0	-40	$596	-$52
2017-18 (intermediate)	40	20	-20		-$26
2018-19 (wet)	40	60	+20		+$26
3-year average	40	27	-13		-$17

Table 2 Comparison of fixed rate (FR) and seasonally modified (SM) DM production for the first autumn grazing cycle*

Trial year and preceding summer	FR N (kg/ha/cycle)	SM DM (t/ha/cycle)	Change in DM (t/ha/cycle)	$/t hay[4]	Change in value of DM ($/ha)
2016-17 (dry)	0.9	0.9	-0.1	$183	-$12
2017-18 (intermediate)	1.2	1.2	+0.0		$4
2018-19 (wet)	1.7	2.2	+0.5		$91
3-year average	1.3	1.4	+0.2		$28

*Figures presented in this table are rounded

On average across the three years, by combining the change in the cost of applied N[3] (Table 1) and the change in the value of DM[4] production (Table 2), analysis shows optimised autumn N application could generate a net benefit of $45/ha/year, with a range from $30 to $65. Variation across the three years of data reflect the influence of underlying seasonal conditions. Following a dry summer, the rate of N was reduced with limited impact on pasture DM[4] production. Conversely, following a wet summer, it was economically beneficial to increase the rate of N fertiliser and pasture DM production.

Compared to the typical fixed rate practice, it was economically beneficial to reduce N application following a dry and intermediate summer and increase N application following a wet summer.

To achieve the benefits of optimised N application and pasture DM production, the MPfN Program research highlighted the importance of understanding soil characteristics, such as soil organic carbon and moisture content. Set-up and ongoing costs to achieve this were calculated via industry consultation (Table 3).

3 N was valued using farmgate urea prices (N content of 46%). Average, high and low urea prices were derived from 5 years of TradeMap imported urea data and Ag Econ data. A spreading cost of $40/t was applied based on Dairy Australia Fert$mart Nitrogen Guidelines. All figures adjusted to 2020 prices.

4 The modelling assumed that increased pasture DM production was converted to pasture hay (with a DM content of 85%) and either used to offset existing supplementary feed or sold at the market price. Conversely, DM was purchased at the prevailing market price to offset any decreases in production. Market values for pasture hay were derived from five years of Dairy Australia Hay and Grain Report data, using prices for South West Victoria, and adjusted for cartage, or the cost of cutting, raking, bailing and field losses as appropriate. All figures adjusted to 2020 prices.

Table 3 Soil moisture monitoring costs (100 ha reference area over 5-year life of equipment)

Cost item	Number of units and cost	Total cost
Soil moisture probes[a]	3 probes @ $650 per probe, with a five-year lifespan and advisor support @ $100/probe.	$2250
Logger-plus[a]	1 unit @ $850	$850
Soil analysis[a]	15 samples @ $95 per sample	$1425
Data access subscription[b]	1 subscription @ $25/month for five years	$1500
Total 5-year cost		**$6025**
Average annual cost per ha		**$12**

[a] Nominal set-up cost.
[b] Nominal ongoing cost. All data gathered through the UoM research team.

The final step in the economic analysis was to combine the potential benefits (the net change in the cost of N applied and the value of the DM response) with the potential costs of soil moisture monitoring. As the cost of soil moisture monitoring was allocated over five years, discounted cashflow analysis was undertaken to compare costs and benefits over the same period. A 5% discount rate was used to convert all nominal (undiscounted) cashflows to equivalent present values (PV). Comparing the average annual PV of benefits (equal to $41/ha) with the average annual PV of costs (equal to $12/ha) generated a positive economic impact of an additional $29/ha/year (Table 4).

Table 4 Net economic impact of using Soil Moisture Monitoring to optimise autumn N application at the Allansford site.

Cost item	Average cost ($/ha/year)	Average benefit ($/ha/year)
Nominal (undiscounted) values	$12	$45
Present values (5% discount rate)[5]	$12	$41
Economic impact (benefits costs)	**$29**	

Sensitivity analysis

To test the sensitivity of results to changes in market price, a range of potential urea, pasture hay and soil monitoring costs were identified. Table 5 shows how the potential impact ($/ha/year) of using soil moisture monitoring to optimise autumn N application at the Allansford site varies across combinations of urea and hay values. For example, when urea and hay prices were $596/t and $183/t respectively, a seasonally modified N strategy, supported by soil moisture monitoring, could generate $29/ha above the typical fixed rate N strategy.

Table 5 Sensitivity of the economic impact ($/ha/year) to changes in urea and DM (pasture hay) values.

		Urea price ($/t)[3]				
		$493	$544	$596	$596	$686
Average hay price ($/t)[4]	$75	$12	$13	$14	$14	$17
	$129	$19	$20	$22	$22	$24
	$183	$27	$28	**$29**	$29	$31
	$253	$45	$44	$43	$43	$41
	$323	$66	$63	$62	$62	$60

Table 6 shows the sensitivity of results to changes in soil sampling and moisture monitoring costs, ranging from +/- 50% of the baseline cost (Table 3). Of note, the farm level cost per hectare will be influenced by individual farm factors such as the topography and variability in soil types.

[5] Investment in soil moisture monitoring was defined by a high proportion of upfront costs resulting in little change from discounting

Table 6 Sensitivity of the economic impact ($/ha/year) to changes in soil moisture monitoring costs.

	Soil moisture monitoring ($/ha)				
	$6	$9	$12	$15	$18
Net impact ($/ha)	$35	$32	**$29**	$26	$23

Importantly, the above sensitivity analysis shows that the economic impact remains positive for a broad range of urea, hay and soil moisture monitoring costs.

Conclusion

By combining economic analysis with the trial results and biophysical modelling research undertaken in the MPfN Program, this case study quantified the lost opportunity of following a fixed recipe for autumn N application. Analysis of the Allansford trial site data showed that by applying a seasonally modified approach to N application, supported by soil moisture monitoring, it was economically beneficial to reduce N application following a dry and intermediate summer, and increase N application following a wet summer. Using three years of trial data, seasonal optimisation led to an average increase in NUE.

ENVIRONMENTAL OUTCOMES

By more accurately matching nutrient supply with plant growth, the seasonally modified N application strategy in this case study also leads to:

- Higher and more consistent DM production and therefore increased ground cover through the year.
- Higher root growth leading to higher soil organic matter.
- Improved nitrogen use efficiency in terms of DM production per unit of N applied.

FOR FURTHER INFORMATION

On the MPfN Program visit **crdc.com.au/more-profit-nitrogen**

For more information on this case study, please contact Cath Lescun, Lead - Soils and Irrigation, Dairy Australia, **Cath.Lesun@dairyaustralia.com.au**

This case study was prepared by the dairy research projects of the More Profit from Nitrogen Program, with the assistance of AgEcon, through the MPfN: final evaluation and economic case studies project. The More Profit from Nitrogen Program: enhancing the nutrient use efficiency of intensive cropping and pasture systems is supported by funding from the Australian Government Department of Agriculture, Water and the Environment as part of its Rural R&D for Profit program.

Australian Government Department of Agriculture, Water and the Environment

Dairy Australia

The University of Melbourne

tia Tasmanian Institute of Agriculture

QUT

This project is supported by funding from the Australian Government Department of Agriculture, Water and the Environment as part of its Rural R&D for Profit program, The University of Melbourne, Tasmanian Institute of Agriculture, Queensland University of Technology and Dairy Australia.

Dairy Australia Limited ABN 60 105 227 987
E enquiries@dairyaustralia.com.au
T +61 3 9694 3777
F +61 3 9694 3701
dairyaustralia.com.au

2584.1 | Sep 2020