Quantifying the whole farm systems impact of nitrogen best practice on dairy farms

The dairy industry has used whole farm system analysis as a cost-effective research tool to assess the potential of a range of N management interventions on dairy farms. This capability can be confidently used to assess the value-proposition of research into new technology and practices at a reduced cost and time relative to field experiments.

Over the last 20 years average annual N fertiliser use on dairy farms has increased more than four-fold, now approximately 100 kg N/ha per annum to over 250 kg N/ha per annum on some farms. When all sources of N input are accounted for, higher stocked farms would be cycling between 400 and 600 kg N/ha annually. The average annual N usage cost per farm is approximately $40,000.

Although research has defined guiding principles for the rate, source, timing and placement of N, there has been little validation of these best management practices (BMP) at a farm systems scale. It is well known that local factors influence the efficiency of N usage, however the effects on production, profitability, N cycling, and N losses at the whole of farm system level have not been well quantified.

This project, led by the University of Melbourne, is using modelling to validate current N BMPs at both the component and farm system level. An important aspect of the work is testing of the current dairy industry's "Fert$mart" guidelines in key dairy regions of Australia. The modelling approach is proving to provide an effective link between high level component research and end users such as farmers, service providers and commercial advisors across regions and varying farming systems.

Assessing the potential for improvement in N use efficiency (NUE) will assist the industry in achieving both productivity and environmental targets, including improvements in home grown forage consumption, water use efficiency, cost effectiveness and greenhouse gas emissions efficiencies.

The research hypothesis

The project aims to use farm systems analysis and modelling to validate recommended dairy N BMPs and undertake new research emanating from the broader More Profit from Nitrogen project.

The key hypotheses are:

- Current BMPs in the Fert$mart guidelines will improve productivity and NUE, while minimising environmental N losses, when implemented in a whole farm systems context;
- N fertiliser rates and timing of application can be targeted to pasture needs if the contribution of soil N mineralisation can be estimated, leading to improved NUE, better production and reduced environmental N losses; and
- Combinations of irrigation management, fertiliser timing and enhanced efficiency fertiliser (EEF) can lead to improvement in production, profitability and NUE at a farm systems scale.

Methodology

The project is undertaking the following key activities:

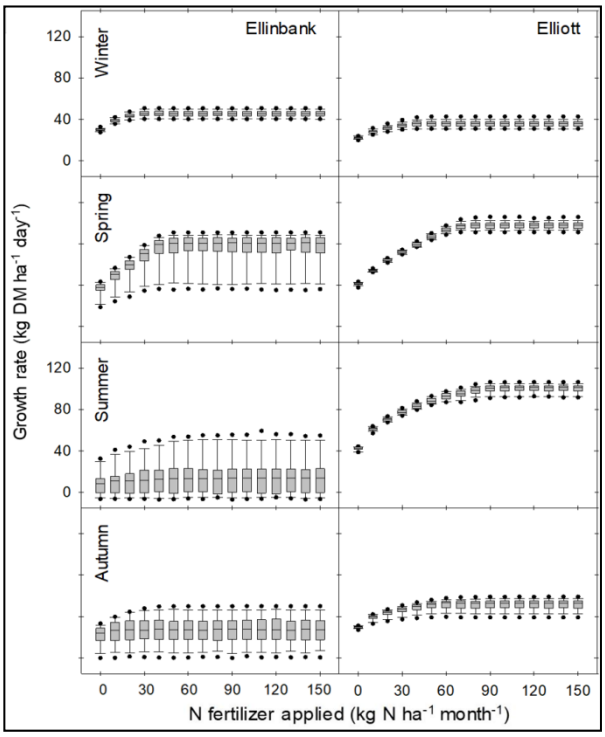
- Establishing farm system simulations to model potential interactions between soil N mineralisation, N application rates, soil and climate for the major dairy regions of Australia;
- Modelling the interacting influences of irrigation management, fertiliser timing and EEF on potential pasture production and NUE;
- Identifying best combinations of irrigation, fertiliser timing and EEF type at a farm systems scale for enhancing dairy farm profitability whilst minimising environmental N losses; and
- Using the resource pool of the broader project to seek input into model development needs and conversely providing evaluation and extension of component level research across regions and farming systems.

The project has used previous farm systems model simulations at Ellinbank and Terang (Vic), Elliott (Tas), Mt Gambier (SA) and Taree (NSW) in initial studies. New model simulations are being established in 2018 at the trial sites of other MPfN dairy research projects including Allansford (SW Vic), Camden and Casino (NSW).

Project Achievements

Two major modelling studies have been completed (explained below) resulting in the publication of a conference paper and two peer reviewed journal articles in the first 18 months. The project has also been involved in the delivery of a number of field days for farmers and conducted two workshops on modelling for researchers and service providers.

Initial Outcomes



The first study examined the effect of a range of N fertilizer rates on pasture production for five dairy sites through south-eastern Australia over 18 years, under both cutting and grazing regimes. For most sites and seasons, current BMPs of applying between 20 and 50 kg N/ha post grazing will ensure efficient use of N applied, assuming soil moisture is not first limiting growth. The modelling therefore validated the current BMPs for the rate of N to apply for both irrigated and dryland systems, from Tasmania through to central NSW.

However, the modelling has questioned the application of N in summer and autumn under dryland conditions in southern Australia, showing almost zero response to autumn N in 6 of the past 18 years at Ellinbank and 10 of the past 18 years at Terang. Only 22% of years at Ellinbank achieved summer N responses close to the economic break-even of 6:1 (i.e. 6 kg extra DM per kg N applied), with a range of between 0:1 and 12:1. These very poor pasture responses to N fertiliser in summer are mainly due to deep soil water limitations. Figure 1 is a comparison of a dryland site (Ellinbank) and irrigated site (Elliott), showing the far greater variability (uncertainty between years) in N response at the dryland site, especially in summer and autumn.

The modelling has therefore highlighted the risk of following a fixed recipe for applying N, particularly in summer and through the dry autumn period.

Figure 1. *The 18-year average pasture growth rate response to N fertilizer (kg DM/ha/day) at Ellinbank, Vic (dryland) and Elliott, Tas (irrigated) over each of the four seasons. Boxplots show the variability between years, being 25% and 75% of years in boxed, with whiskers representing 10% and 90% of years.*

The second study used the same five dairy sites to compare the practice of applying a flat monthly rate of N fertiliser to increasing levels of strategic approaches to determine the rate and timing of N fertiliser. The study has found that more tactical/strategic application of N within season was more likely to result in economic pasture production response (as shown in study 1), a significant reduction in N application rates, reduced N losses and increased NUE. Moving beyond this initial step of a more strategic N application approach, to using increasing levels of precision technologies may incrementally improve NUE further.

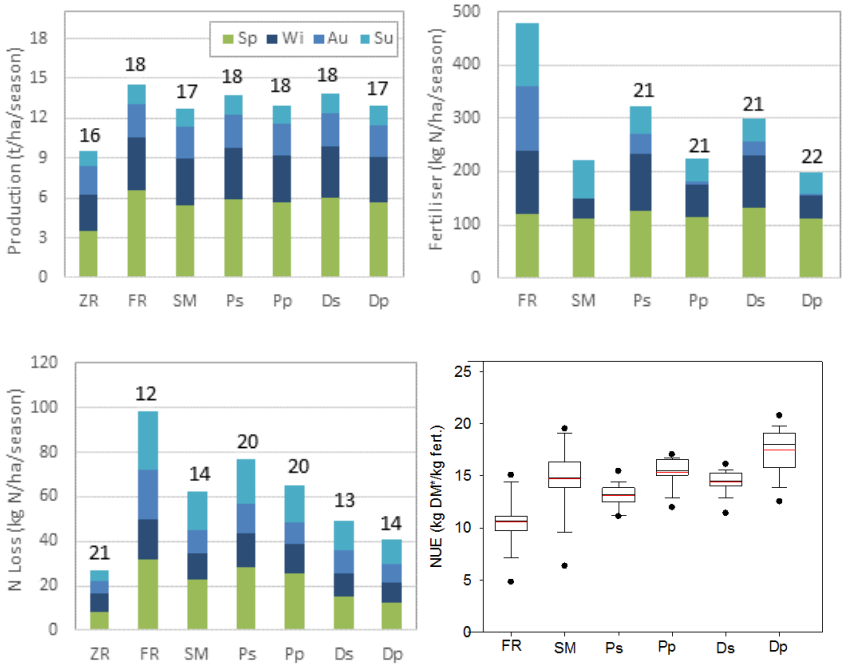


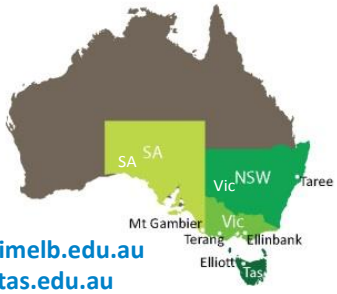
Figure 2. *Total dry matter production (top left: t DM/ha/season), N fertiliser rates (top right: kg N/ha/season), total N loss (bottom left: kg N/ha) and NUE (bottom right: kg DM/kg N fertiliser), comparing a flat rate of 40 kg N/ha per month (FR) with strategic approaches and technology to determine the rate and timing of N fertiliser at Ellinbank. Bar colours are from bottom to top – autumn, spring, summer, winter. Coefficient of variation of the annual totals are given above the bars.*

(ZR= Zero N applied; FR = Flat rate after each grazing 40 kgN/ha dryland & 50 kg N/ha irrigated; Seasonally modified (SM) = strategic application based on paper 1; Precision agriculture soil (Ps) = 30 kg/ha applied when soil N <20 mg/kg in the top 15cm and not applied for at least 21-days; Precision agriculture - plant (Pp): as per Ps, except applied when leaf N drops below 90% of optimum; Optimal N daily - plant (Dp): as for Pp except N applied daily; Optimal N daily - soil (Ds): as for Ps except N applied daily)

Extending the outcomes

The outcomes of this project are being extended through the following channels.

- **Science**
  - Published scientific papers on validating existing BMPs and evaluating potential of digital technologies in improving NUE.
- **Industry**
  - Workshops with regional dairy coordinators to update them on N BMPs for regions and farming systems.
  - Presentation of research findings at dairy industry and science conferences.
  - Presentation and discussion of research to farmers and advisors at regional field days and through industry publications.
  - Updating of the Fert$mart guidelines and publication of a fact sheet on key changes for the dairy industry.
- **Service Providers**
  - Annual professional skill development workshop with modellers, dairy consultants and dairy extension officers to share and enhance their modelling skills.



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

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