More Profit from Nitrogen:  
Quantifying the whole farm systems impact of nitrogen best practice on dairy farms  
(RRDP1716)

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Australian Government Department of Agriculture, Water and the Environment  
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Melbourne and Tasmanian Institute of Agriculture
Current project team & roles

- The University of Melbourne:
  - Richard Eckard - Project Leader
  - Andrew Smith – Farming Systems Modelling (now left)
  - Rachelle Meyer – Farming Systems Modelling
  - Karina Marsden – Marie Curie Fellow, Bangor Uni
  - Esmée de Loof – Masters Student, Wageningen
- Tasmanian Institute of Agriculture
  - Richard Rawnsley – Project co-Leader (now left)
  - Karen Christie – Farming Systems Modelling
  - Matthew Harrison – Farming Systems Modelling
Project objective

- Modelling to validate recommended N-BMPs for dairy

**Methodology**

- Evaluate the value of N-BMPs (Fert$mart$)
  - Soil x climates x seasons x years
- How?
  - DairyMod et al.
- Sites modelled
  - Ellinbank, Terang, Elliott, Allansford,
  - Mt Gambier, Camden, Casino, Taree
Key drivers of ammonia volatilisation and nitrate leaching

Karen Christie
- Modelled 18 years at Ellinbank
  - 20, 40, 40 and 10 kg N/ha.month
  - winter, spring, summer and autumn
- N volatilisation vs
  - Mean monthly daily temperature and rainfall
- Leached N vs
  - monthly rainfall and drainage
- Soil N concentration
  - NH$_4^-$-N (top 10cm soil)
  - NO$_3^-$-N (top 40cm soil)
Key drivers of ammonia volatilisation

- Increased temperatures => increased volatilisation
  - Except during summer
  - Flat-lined if two highest volatilisation dots removed

- Size of the soil N pool (dot size) also important
  - Spring and autumn with similar temperatures
Key drivers of nitrate leaching

- Increased rainfall => increased N leaching
  - Greater losses in winter and spring
Key drivers of nitrate leaching

- Increased rainfall => increased N leaching
  - greater losses in winter and spring
- Drainage is highest driver
  - soil NO$_3$-N concentration a contributing factor
  - Comparison of dot size in spr/sum vs aut/win)
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Summary of ammonia volatilisation and nitrate leaching

- **Volatileisation** - Farmers can’t alter temperature
  - So reduce N loading on the soil
  - Especially during late spring and summer, to reduce N volatilisation

- **Leaching** - Farmers can’t alter rainfall
  - Can manage drainage (to some extent) and N loading
  - Manage autumn / early winter N fertiliser to reduce soil N loading in late winter and into spring
Soil N: can pasture yields be increased by capitalising on seasonal trends in mineralisation or immobilisation?

Matt Harrison

• What is the effect of timing of N application on N mineralisation and pasture growth?
  o Could we apply N in December to stimulate long-term mineralization?

• Modelled Hamilton (Vic)
  o Vertosol and chromosol soils
  o 100 kg N/ha on 1 August OR 1 December
  o 20 year continuous simulations
  o Pastures cut on monthly basis with litter returned to the soil
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Seasonal N mineralisation

100 kg N/ha OR 100 kg N/ha
December N fertilisation resulted in higher mineralisation in both soil types – year round.
December fertilisation resulted in higher pasture growth rates in 7 months of the year.

August fertilisation resulted in greater growth only in two months.
Long-term pasture growth rates

Mean of both treatments was 7.8±1.6 t DM/ha, i.e. no difference in long-term pasture production.
Summary – Soil N mineralisation

• Applying N in August vs December
  o greater plant N uptake and less mineralisation
  o Relieved N stress and incremented growth rates in August and September
  o long-term effects were not significant

• August N - higher N concentration in litter
  o Lower potential for immobilisation compared with the December

• December N – longer period of mineralization
  o But no long-term benefit.
Effects of excess dietary nitrogen on milk production

“A model to predict the effect of excess dietary nitrogen on milk production and its implications for reducing nitrogen inputs on pasture-based dairy farms”

MSc thesis Esmée de Looff, March 2019
Wageningen University (Netherlands)
University of Melbourne
Introduction

- Energy cost to metabolise N in excess of requirement
- Research question – Quantify potential milk loss
- Hypothesis – highest milk losses from diets high in pasture (CP) during spring

A. Smith, University of Melbourne, Australia (pers. comm.), Dairy Australia (2019), Ludemann et al. (2015)
Method – model development

→ Major part of study
→ cow-level => E balance, N balance, milk loss from excess N

Cow (bodyweight, calving)
Milk (L, %P, %F)
Diet

• Ingredients
• Dry matter intake
• Energy & protein content

Model in Excel

Estimated (!) milk losses

Climate? Animal health? Age? …
Method – model application

Three case studies, based on diet and milk production

Pasture inclusion in diet

HS diet  Lower % pasture 7500L/yr
MS diet  Medium % pasture 6500L/yr
LS diet  Higher % pasture 5500L/yr
Outcomes

• Average: 3% milk loss/day (0.75L/day on 25L/day production)

• Highest milk losses for diet with highest % pasture

• Highest NUE for diet with lowest % pasture  
  ➔ improved ME:CP

Pasture CP content

Oversupply of dietary N
Summary - excess dietary N

- Diets high in pasture content - higher seasonal CP variation
- Model shows when to address issue excess dietary N
- Further research needed to quantify economic implication for farmer
- Encourages precision nutrition and precision fertiliser

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**Best Management Practices for nitrogen (N) fertiliser use on dairy pastures**

The following Best Management Practices were developed to ensure maximum nitrogen use efficiency (NUE), while also minimising avoidable environmental losses.

**General guidelines for N management**

- **Apply N strategically, rather than by fixed recipe**: Before each N application estimate the likely N response (i.e. from lookup tables, experience, consultants) and compare the cost of the additional pasture produced to other purchased feed options.
- **Only apply N when pasture is actively growing and can utilise the N**: Ensure that soil moisture is adequate to sustain the regrowth, rainfall is likely in the regrowth period, temperatures are conducive to good pasture growth, there is a good species composition and other major soil nutrients are within Fert$mart parameters.
- **Apply N at rates of 20 to 50 kg N/ha per application, no closer than 21 to 28 days apart**: It can also be useful to combine the rate by interval as 1.0 to 1.75 kg N/ha per day. During the peak growth period, with newer cultivars, it may be justified to increase the upper rate to 2 kg N/ha per day.
- **Ensure that the extra pasture grown is utilised**: either through grazing or as harvested forage, as utilisation has a big impact on the economics of using N.

**New issues added:**

- Soil moisture over summer/autumn
- Urease and nitrification inhibitors
- Soil N mineralisation
- Animal health

- Joint effort by all dairy projects
- Pocket guide produced by spring
- On-line Fert$mart BMPs updated
Science outputs


Visit

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