Improving Nitrogen Cycling Efficiency of Intensively Grazed Pastures Using Nitrification Inhibitors

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New Zealand grazed pastures

- The predominant land use in NZ is grazed pastures.
- Pastures: Perennial ryegrass and white clover.
- Different from the feed-lot systems, e.g. in parts of North America, Europe, and Asia.

US feedlot

New Zealand grazed pasture system

Ryegrass and white clover

Major land use changes in New Zealand

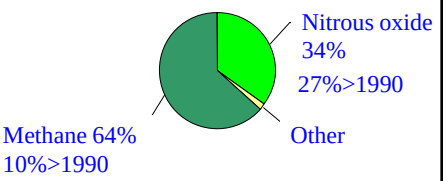
- Land use change:
  - Dramatic decrease in sheep farming, dropping from more than 70 million to fewer than 40 million sheep.
  - Dramatic increase with dairy farming with dairy cow numbers reaching > 5 million.
- Increased intensification: higher stocking rates and fertiliser use.
- Rising public concern of adverse environmental impacts with nitrogen losses.

Major environmental issues associated with N losses

- Nitrate (NO_3^-) leaching and water contamination:
  - Risk to drinking water;
  - Surface water eutrophication.
- Greenhouse gas (GHG) emissions: Nitrous oxide (N_2O) is a potent GHG.
- Agriculture accounts for 50% of NZ's total GHG.

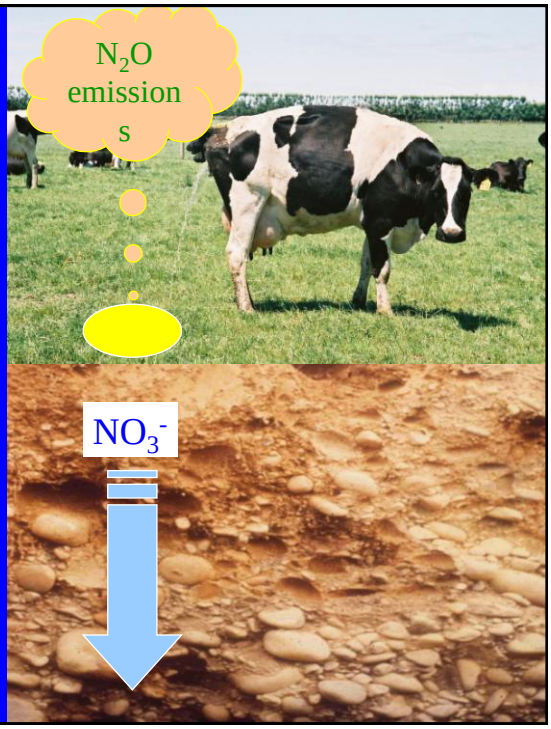
Algal blooms

Greenhouse gas emissions from NZ agriculture (2005)

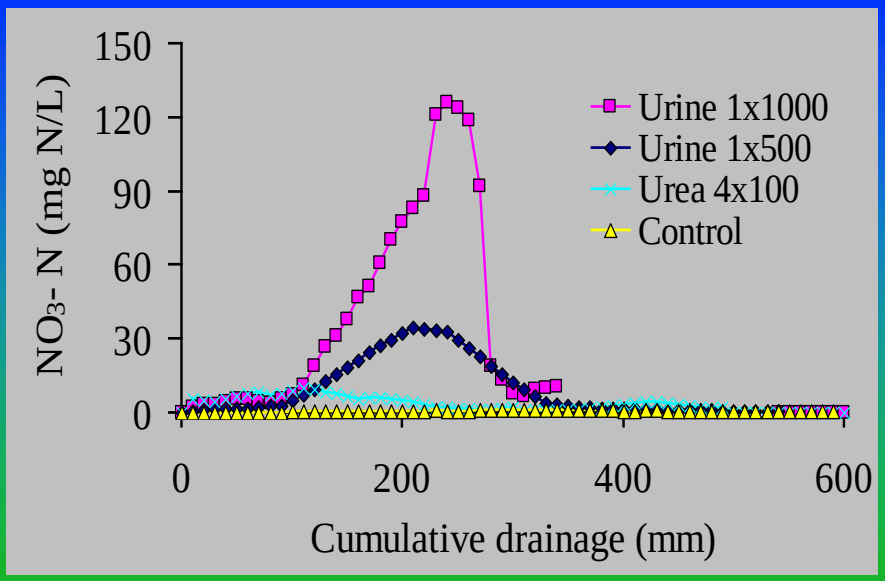


Sources of NO_3 leaching and N_2O emissions in grazed pastures:

- In grazed pastures, urine patches are the main sources of both NO_3^- leaching and N_2O emissions.
- Direct losses from N fertilisers are relatively small.



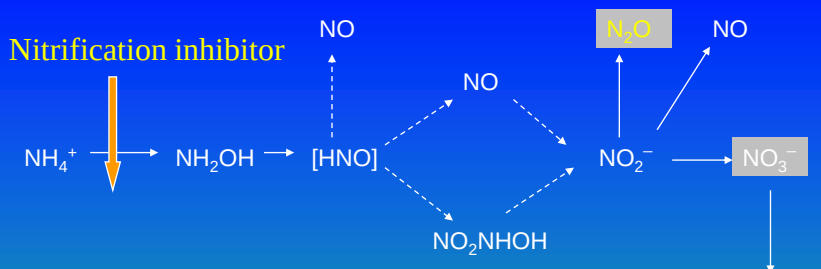
Nitrate leaching from animal urine and urea (Di and Cameron, 2002)



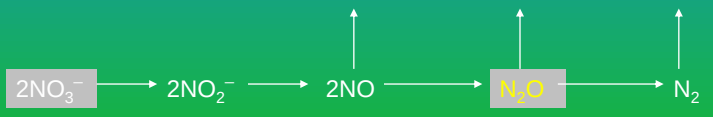
Challenges in mitigating N losses

- Urine is deposited randomly at different times across grazed fields.
- It is a real challenge to mitigate nitrate leaching and nitrous oxide emissions from these urine spots.
- One of the recent developments is the use of nitrification inhibitors to treat grazed pasture soils to reduce nitrate leaching and nitrous oxide emissions.

Theory behind the use of nitrification inhibitors



Nitrification



Denitrification

How to apply nitrification inhibitors

- Ammonium oxidising microbes are everywhere in the soil.
- It is important to treat the entire soil surface.
- One of the ways to achieve this is to apply nitrification inhibitors in a fine particle suspension spray.

When to apply nitrification inhibitors

- In New Zealand most of the nitrate leaching occurs during late autumn-winter-early spring (May to September).
- Nitrate leaching is minimal during the summer because of water loss by evapotranspiration and fast plant uptake of N.
- Therefore nitrification inhibitors are used during the high leaching period from late autumn to early spring.

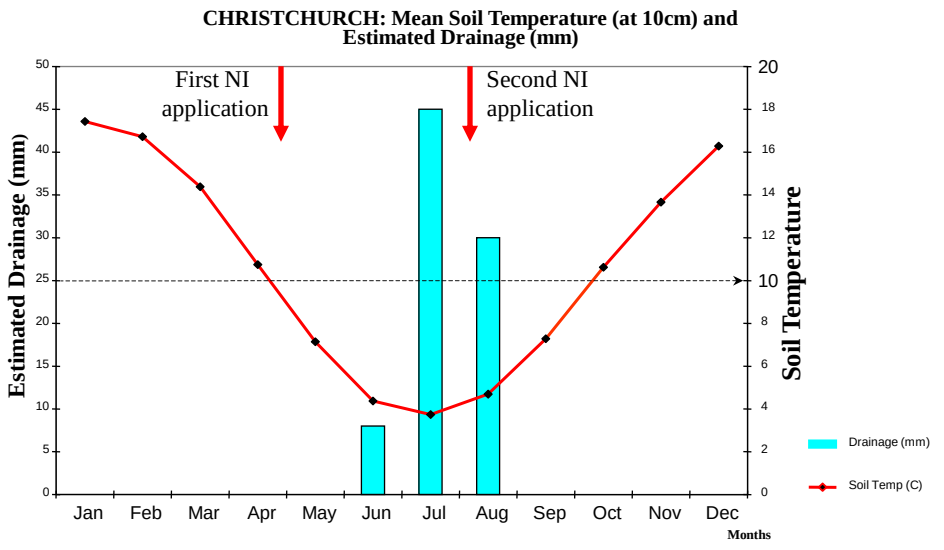
How many times to apply nitrification inhibitors

- The longevity of nitrification inhibitors in soil is affected by soil temperature:

Half-lives of DCD as affected by temperature
(Di and Cameron, 2004b)

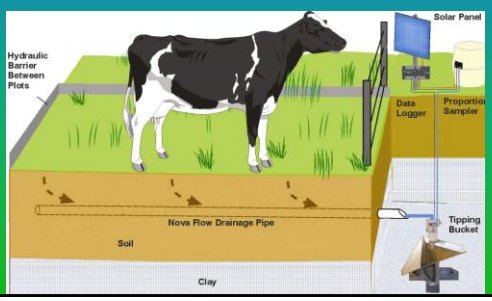
Temperature (°C)	Half-life (days)
8	111
20	25

Two applications recommended in New Zealand: *Autumn and again late winter/early spring*



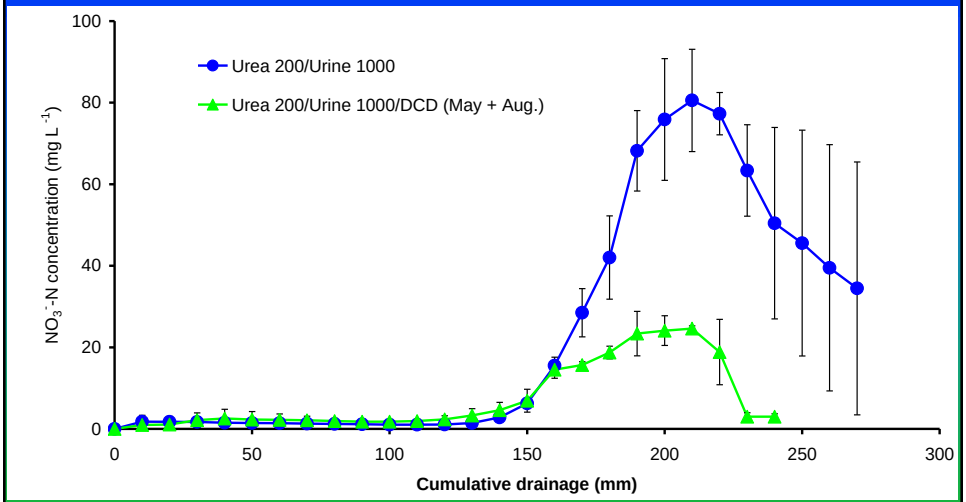
Research to assess the effectiveness of inhibitors

- Lysimeter studies.
- Field plots.
- On-farm trials.

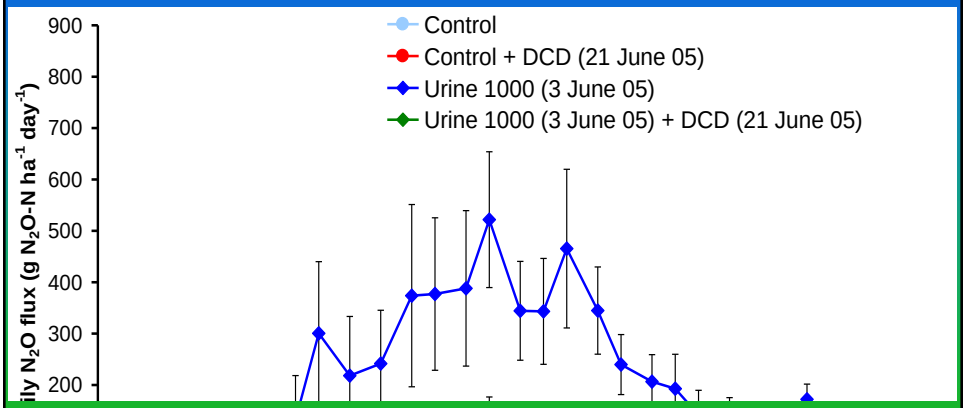


Benefits of using nitrification inhibitors:

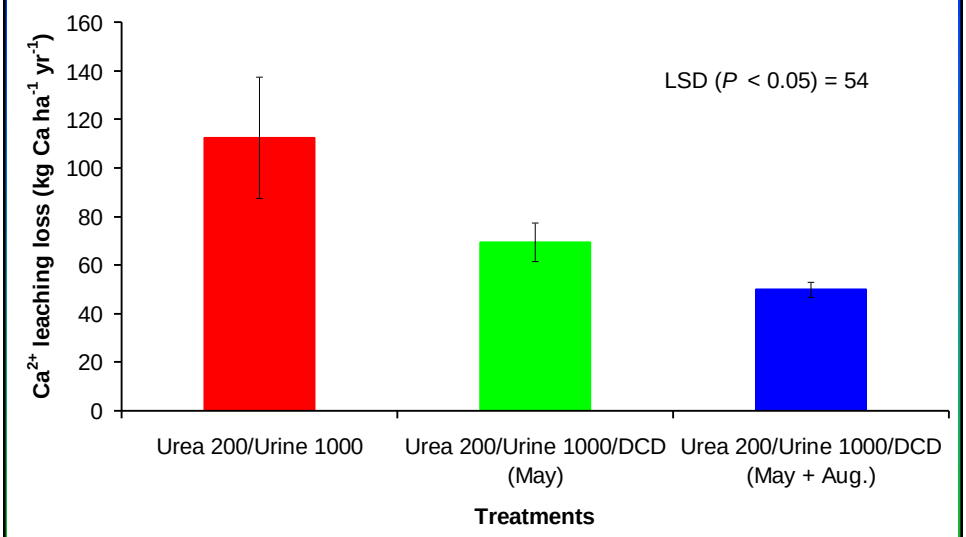
Nitrate leaching reduced by about 60% (Di and Cameron, 2004a)



Benefits of using nitrification inhibitors:
Nitrous oxide emissions reduced by about 70% (Di et al., 2007)

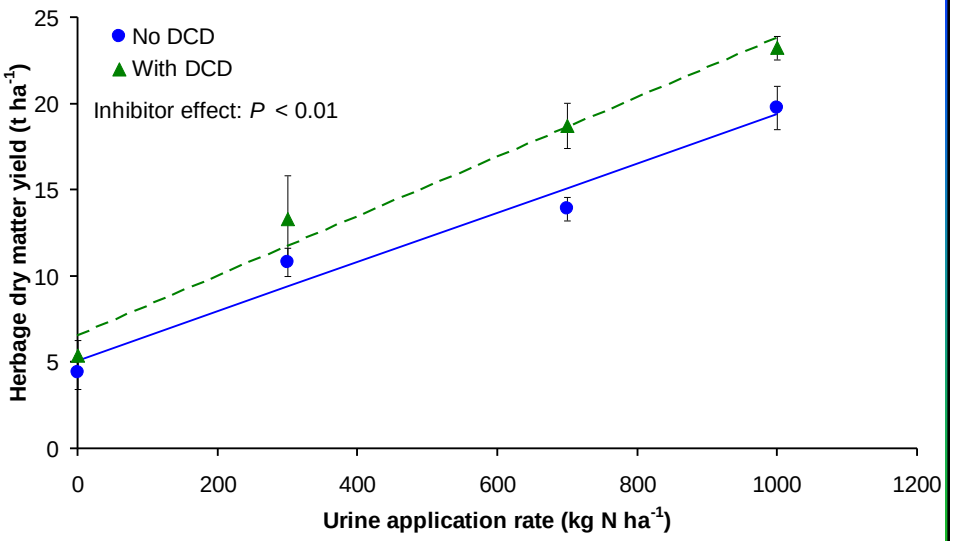


Benefits of using nitrification inhibitors:
Cation leaching reduced by about 50% (Di and Cameron, 2004a)

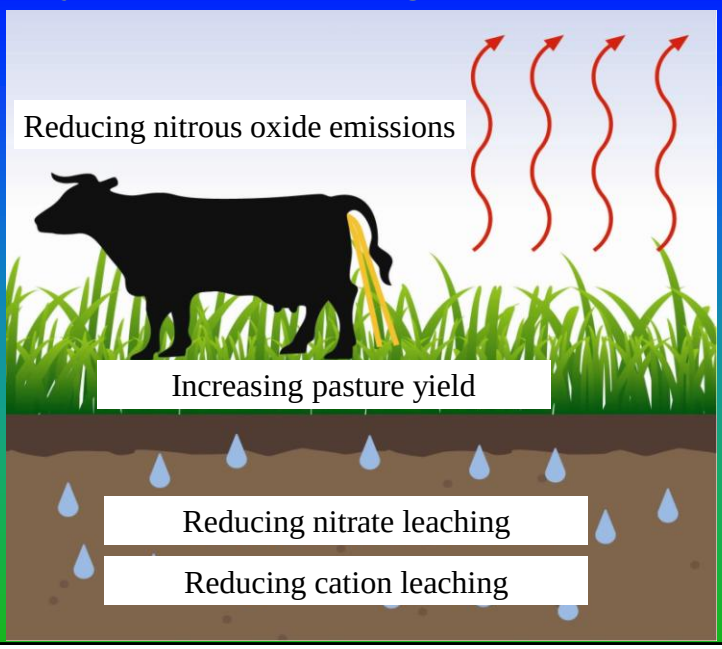


Benefits of using nitrification inhibitors:

Pasture yield increased by more than 20% (Di and Cameron, 2007).



Summary of benefits of using nitrification inhibitors



All these data available in refereed publications

1. Di HJ and Cameron KC (2002) *Soil Use and Management* 18: 395-403.
2. Di HJ and Cameron KC (2003) *Soil Use and Management* 19: 184-290.
3. Di HJ and Cameron KC (2004a) *Soil Use and Management* 20: 2-7.
4. Di HJ and Cameron KC (2004b) *NZ Journal of Agricultural Research* 47: 351-361.
5. Di HJ and Cameron KC (2004c) *Australian Journal of Soil Research* 42: 927-932.
6. Di HJ and Cameron KC (2005) *Agriculture, Ecosystems and Environment* 109: 202-212.
7. Di HJ and Cameron KC (2006) *Biology and Fertility of Soils* 42: 472-480.
8. Di HJ, Cameron KC and Sherlock (2007) *Soil Use and Management* 23*: 1-9.*
9. Moir JM, Cameron KC and Di, HJ (2007) *Soil Use and Management 23: 111-120.*
10. Clough TJ, Di HJ, Cameron KC, Sherlock, RR, Metherell AK, Clark H and Rys, G (2007) *Nutrient Cycling in Agroecosystems 78: 1-14.*
11. Di HJ and Cameron KC (2007) *Nutrient Cycling in Agroecosystems* 79: 281-290.
12. Di HJ and Cameron, KC (2008). *Australian Journal of Soil Research* 46: 76-82.

Potential use in grazed pastures in other countries

- The degradation rate of nitrification inhibitors increase with temperature.
- The technology is thus best suited to cool temperate regions of the world with pastoral grazing, e.g.:
  - Southern Australia (Southern Victoria and New South Wales, Tasmania);
  - Parts of South America: e.g. Uruguay, Chile;
  - Parts of North America with pastoral grazing;
  - Northern Europe with pastoral grazing;
  - Parts of North Asia with pastoral grazing.

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