

**Project number:** 6429

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## Minimising urinary nitrogen output from dairy and beef cattle in pasture-based production systems



### Key external stakeholders:

Policy makers, dairy farmers, beef farmers, agricultural advisors.

### Practical implications for stakeholders:

Intensification of pasture-based production of milk and meat may increase urine nitrogen (N) loss leading to increased nitrate leaching potential and nitrous oxide emissions.

- Equations have been developed to allow prediction of N losses from cattle in pasture-based production systems.
- Decreasing N consumption seems to be the most effective strategy for decreasing N losses to the environment.

### Main results:

- From an interrogation of published literature, N intake was the principal factor in predicting N excreted in urine by cattle.
- Decreasing the N concentration in pasture by decreasing N fertilisation rate and supplementing pasture with a low-protein, high-energy feed decreased total and urinary N excretion by beef cattle.
- Decreasing the N concentration of supplementary concentrate decreased urinary N excretion by lactating dairy cattle on pasture-based systems.
- Inclusion of white clover, at 20% of dry matter intake, can sustain milk production with no adverse effect on N utilization efficiency of lactating dairy cows when offered in combination with low N concentrates and pasture.

### Opportunity / Benefit:

- Equations derived from this project can be used to estimate urinary N loss to the environment from grazing cattle.
- Dietary management strategies to mitigate these losses can be identified and recommended from application of the equations.

### Collaborating Institutions:

UCD

AFBI, Northern Ireland

<b>Teagasc project team:</b>	Dr Aidan Moloney (Project Leader) Dr Pdraig O'Kiely (Former Project Leader) Dr Richard Dewhurst (Former Project Leader) Dr Mark McGee Dr Donal O'Brien Dr Paul Cormican Dr Paul Crosson
<b>External collaborators:</b>	Dr Bridget Lynch, Dr Tommy Boland (UCD) Dr Tianhai Yan (AFBI, Northern Ireland)

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### 1. Project background:

The efficiency of converting herbage protein into milk and meat protein is central to efficient and sustainable milk and beef production systems. This requires new understanding of the effects of grassland management on herbage composition and subsequently, on N losses to the environment and greenhouse gas (GHG) emissions. This information could be incorporated into farm practice, as well as into models of GHG emissions used for Ireland's GHG inventory. The challenge for Ireland is to intensify production in pasture-based systems, exploiting a major competitive advantage, while minimizing environmental impacts. The major problem with this 'intensification' will be increased herbage N content: associated with improvements in grazing management, increased N fertiliser use, and the use of legumes to increase productivity. The combination of increased stocking rates and herbage N concentration results in a large increase in urine N excretion per hectare, leading to increased nitrate leaching potential and nitrous oxide emissions.

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#### Questions addressed by the project:

- Identify grassland management strategies that maximise herbage intake and animal productivity, without increasing urine N.
- Identify and test animal, diet and other management factors that affect N partitioning, urine N output and urine N concentration.
- Model the effect of management changes designed to reduce urine N output and urine N concentration in dairy cows using data from full lactations.
- Incorporate findings from the project into whole-farm models of GHG emissions.

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### 3. The experimental studies:

- Datasets from previous studies were assembled and interrogated to understand influences on herbage composition (*what other feed components change when herbage N alters? how are these relationships affected by management?*) and herbage intake (*how does herbage N affect feed intake?*).
- Datasets were also assembled on N partitioning data from studies with conserved grass/concentrates to identify *what factors affect the quantity and concentration of N in urine?*.
- The outcome of these desk-based studies guided experiments undertaken with lactating cows (Hillsborough) and beef cattle (Grange) offered grazed grass. Approaches included variations in grassland management, concentrate supplementation, N balance and methane production *in vivo* (Hillsborough) and *in vitro* (Grange) measurement.
- Equations were derived to allow prediction of urinary N losses in dairy cows based on milk urea N concentrations. These equations were applied to three different studies in which the data were available for a full lactation.
- Data from the project were incorporated into modified models of GHG emissions.

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### 4. Main results:

The main grassland management factors that influenced herbage digestibility and crude protein concentration were:

- cutting regime
- harvest season
- length of regrowth and
- fertiliser N application rate

Fertiliser N application rate and length of regrowth are more practical tools for altering herbage composition. The requirement to balance herbage yield and 'quality' restricts the extent to which stage of growth can realistically be utilised to manipulate grass composition in practice.

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Regression equations were derived to relate grass nutritional composition and intake with urine volume, urinary N concentration and urinary N output. N intake was the principal factor in predicting daily urinary N excretion.

*In vivo* (animal) experiments examining the effects of fertiliser N application rate to pasture on N metabolism in zero-grazed beef cattle for autumn, spring and summer pasture and the effects of carbohydrate supplementation on N excretion in zero-grazed beef cattle showed that reducing fertiliser N application rate to temperate grass and supplementing grass with a low-protein, high-energy feed are strategies to reduce total and urinary N excretion. These findings are supported by *in vitro* studies using rumen simulation fermenters. Reducing N concentration of the supplementary concentrate may be a successful method of reducing urinary N excretion of lactating dairy cattle on pasture-based systems.

A zero-grazing experiment investigated the effect of white clover (WC) inclusion on performance, nutrient digestibility and N utilization of lactating dairy cows fed fresh perennial ryegrass *ad libitum* and low crude protein concentrates. The data indicate inclusion of WC at 20% of dry matter intake may sustain milk production with no adverse effect on N utilization efficiency of lactating dairy cows when offered in combination with low CP concentrates and good quality fresh perennial ryegrass.

Equations have been developed to predict urine N excretion using milk urea N as sole predictor or in combination with dietary N content. Modelling of urinary N loss in full lactation studies using these equations showed: little effect of breed or multiparous cows; inclusion of white clover in grass pasture can reduce urine N per kg energy corrected milk yield; increasing stocking rate and concentrate input can increase urine N per kg energy corrected milk yield.

#### 5. Opportunity/Benefit:

Reducing fertiliser N application rate to temperate grass and supplementing grass with a low-protein, high-energy feed are practical strategies to reduce total and urinary N excretion, which reduced environmental footprint of grass-based dairy and beef production.

#### 6. Dissemination:

##### Main publications:

Hynes, D. N., Stergiadis, S. Gordon, A. and Yan, T. (2016) 'Effects of N levels in concentrate supplements on animal performance and N utilization of lactating dairy cows fed fresh-cut perennial grass' *Journal of Dairy Science* 99: 8111-8120.

O'Connor, A., McGee, M., Moloney, A., Boland, T. and O'Kiely, P. (2019) 'Digestion and N metabolism in beef cattle and *in vitro* rumen fermentation of autumn grass differing in fertilizer N application rate' *Grass and Forage Science*, 00:1-13. <https://doi.org/10.1111/gfs.12420>.

O'Connor, A., Moloney, A., O'Kiely, P., Boland, T. and McGee, M. (2019) 'Effects of fertiliser nitrogen rate to spring grass on apparent digestibility, nitrogen balance, ruminal fermentation and microbial nitrogen production in beef cattle and *in vitro* rumen fermentation and methane output' *Animal Feed Science and Technology* (Accepted for publication).

##### Popular publications:

O'Connor, A., Moloney, A.P., McGee, M. ExcessN project outline. Grange Beef Open Day 5 July, 2016.

Zhao, Y.G., Hynes D. and Yan, T. Reducing the environmental impact of dairy cattle, AFBI On-Farm Dairy Events, 12-14 September, 2017.

#### 7. Compiled by: Dr Aidan Moloney and Dr Mark McGee