



# Focus on forages to reduce urine patch N leaching

Practical options for reducing the environmental impacts of intensive, pasture-based livestock systems are required to help farmers meet stringent regulations on nitrate leaching.

## Key findings

- The urine patch is the major source of nitrogen loss to the environment on dairy farms.
- Different forages can be used to reduce nitrate leaching, either by lowering the nitrogen loading in urine patches or increasing nitrogen uptake from the urine patch.
- Nitrogen concentration of urine from cows grazing plantain was significantly lower than for cows grazing perennial ryegrass-white clover based pasture.
- Italian ryegrass significantly reduced nitrate leaching compared to perennial ryegrass-white clover pastures. This was due to greater cool season plant growth increasing nitrogen uptake during late-autumn, winter and early-spring.
- Plantain and Italian ryegrass based pastures may be useful for reducing nitrate leaching while maintaining or increasing milksolids production.



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## Introduction

Nitrogen (N) from urine patches is a major contributor to N leaching<sup>1</sup>, due to the high loading rate of N in urine patches compared with the capacity of many plant species to take up the N. There are two ways in which plants can be used to reduce nitrate leaching losses.

First, by growing forages that lead to livestock excreting urine with a lower concentration of N. Second, by using forages to increase N uptake from the urine patch once the urine is deposited on the soil surface. The Forages for Reduced Nitrate Leaching (FRNL) programme is investigating both pathways.

## Lower N loading in the urine patch

Previous studies have demonstrated that cows grazing 'diverse' pastures containing the herbs plantain (*Plantago lanceolata*)

and chicory (*Cichorium intybus*) excrete urine which has lower N concentrations compared with cows grazing standard perennial ryegrass-white clover pastures<sup>2,3</sup>.

More recent studies have focussed specifically on feeding plantain as a strategy to reduce nitrogen excretion. At Lincoln University, milk production and urinary N concentration were measured in late lactation dairy cows grazing a perennial ryegrass-white clover pasture, pure plantain, or a pasture comprised of 50% perennial ryegrass-white clover and 50% pure plantain by ground area. All cows were offered a similar herbage allowance (Table 1)<sup>4</sup>.

Table 1. Mean milk yield and composition for dairy cows grazing perennial ryegrass-white clover pasture, plantain or 50-50 pasture-plantain<sup>4</sup>.

	Standard Pasture	Pure Plantain	50% Pasture Plantain
<b>Milk</b>			
Milksolids (kg/cow/day)	1.50	1.67	1.60
Milk protein (%)	4.28	4.34	4.29
Milk fat (%)	6.16	5.80	5.52
Lactose (%)	4.95	5.05	5.07
Milk urea (mmol/L)	11.2	9.9	10.9
<b>Urine</b>			
N concentration (g N/L)	5.4	2.4	3.6
<b>Faeces</b>			
%DM	10.9	15.7	12.6
N (%)	3.4	3.5	3.3

Daily milksolids production per cow was 0.17 kg MS greater for cows grazing plantain than cows grazing pasture, with cows grazing 50-50 pasture-plantain intermediate. A striking result was that the urine-N concentration was 56% lower for plantain and 33% lower for 50-50 pasture-plantain than pasture. Previous studies have shown that the excretion of N in urine is linearly related to N intake<sup>5</sup>. However, in this experiment the difference in apparent N intake between pasture and plantain was small at 11 g N/cow/day, and is unlikely to be sufficient to explain the large difference in urine N concentration. Subsequent studies have indicated that cows grazing the plantain excrete a greater volume of urine which may have contributed to lower N concentration through dilution. Indeed, there is direct evidence to show that plantain causes a diuresis effect (increased urination) when it is ingested by sheep, possibly by reducing reabsorption of water in the kidneys<sup>6</sup>.

Thus, plantain could offer a pathway toward reducing nitrogen

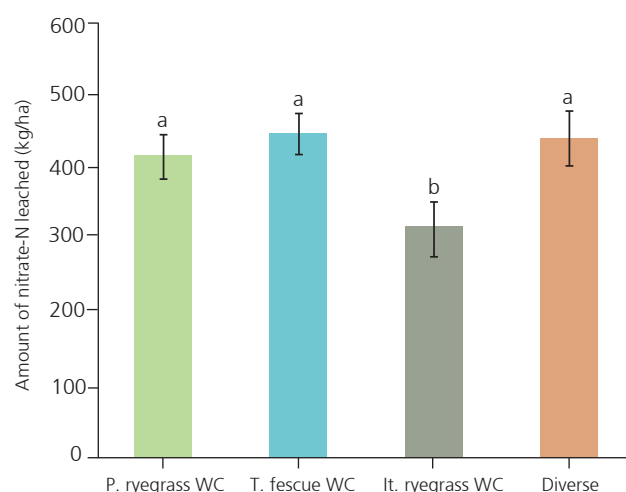
losses to the environment without negative impacts on milk production. The focus of research is now turning to identification of the best ways to capture the potential benefits of the plants in a whole farm system, and ensuring that farmers get credit for adopting the mitigation in the Overseer model.

## Capturing soil nitrate

Initial glasshouse studies with a range of grass, legume and herb species have shown a strong positive relationship between N uptake in the cool season and lower nitrate leaching loss<sup>7</sup>. Building on this, lysimeter studies in FRNL have compared nitrate leaching losses from a range of pasture mixes. Large undisturbed soil monolith lysimeters (50 cm diameter x 700 cm deep) were collected from the different pasture mixtures on the Lincoln University Research Dairy Farm and treated with urine to measure the leaching loss. In the first of three studies<sup>8</sup>, nitrate leaching from simulated urine patches was measured under four different pasture types: perennial ryegrass/white clover (P. ryegrass WC), tall fescue/white clover (T. fescue WC), Italian ryegrass/white clover (It. ryegrass WC) and perennial ryegrass/Italian ryegrass/white clover/red clover/chicory/plantain (Diverse).

Nitrate leaching losses were at around 25% lower under Italian ryegrass WC than under the other pasture species examined (Figure 1).

Figure 1: Total amount of nitrate-N leached from urine patches in the 2011/12 lysimeter study (NB the N loss from the paddock will be a fraction of this loss depending on the urine patch coverage). Means with a letter in common are not significantly different at the 5% level<sup>8</sup>.



The reduction in nitrate leaching under Italian ryegrass WC was attributed to the greater growth rate, and therefore uptake of N from the soil, of the Italian ryegrass during the winter months. Nitrogen uptake of It. ryegrass WC was 1.63 kg N/ha/d, compared with 1.35 kg N/ha/d for P. ryegrass WC and 1.425 kg N/ha/d for T. fescue WC. A second study, conducted in the

Waikato, found no significant difference in nitrogen uptake between *P. ryegrass* and *T. fescue* which, when compared with the Canterbury study, was possibly due to the warmer winter conditions in the Waikato allowing the *T. fescue* to continue growing. Thus, forage options for reducing the nitrate leaching problem may not conform to a 'one size fits all' solution: different forages may work better in some regions than others, depending on the growth characteristics of the species, the regional climate and the timing of the main drainage periods during the year.

In the third study<sup>9</sup>, nitrate-N leaching losses were again lower (35%) from Italian ryegrass than from perennial ryegrass/WC. This study also included lucerne as a comparison. N losses from the lucerne crop were nearly double those from perennial ryegrass/WC, probably because of the low cool-season growth and, therefore, low N uptake of the lucerne. Poor N uptake in cooler seasons resulted in an excess of nitrate remaining in the soil which was ultimately leached over the main drainage period during the winter.

### Future work

These findings were achieved under controlled experimental conditions, and so the N leaching reduction in a commercial setting must be determined. In addition, future experiments will determine the amount of plantain needed in the diet to reduce urinary N, and if mixtures of plantain and Italian ryegrass will offer even greater reductions in N leaching than those associated with one species alone.

### Acknowledgement

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