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FOLLOWING THE NITROGEN: EXPLAINING THE REASONS FOR DECREASED N LEACHING IN THE WAIKATO P21 FARMLETS

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Abstract

The objective of Phase 2 of the Pastoral 21 (P21) programme was to increase the profitability of pastoral farming while reducing its environmental footprint. A dairy farmlet study was set up in the Waikato to compare a system currently typical of that region ('Current') with a modified system focusing on improved nitrogen (N) management ('Future'). Four years of measurements and modelling of N flows through each farmlet were undertaken from 2012 to 2016. The mean reduction in N leaching loss calculated for the Future farmlet was 43% (from 54 to 31 kg N/ha/year for the Control and Future farmlets, respectively). Approximately half of this reduction was achieved by decreasing inputs of N from fertiliser and feed (accompanied by stocking fewer animals). Modelling and measurements of urinary N excretion indicated that the other half of this reduction was achieved by using a standoff pad during March-July to reduce urinary N deposition to pasture, prior to the onset of winter drainage.

Waikato Farmlet Design & Methodology

Current and Future farmlets

The objective of the P21 Waikato dairy farmlet study was to reduce N leaching losses by 30-40% while maintaining productivity and profitability. Two dairy farmlets were set up near Hamilton in 2011 to compare a dairy system typical of the Waikato region ('Current') with a system designed to reduce N leaching losses through lower N inputs and a lower stocking rate, and standing cows off pasture for 5-15 hours/day during March-July ('Future') (Table 1). Further management details are provided by Roach et al. (2016). The dairy platform consisted of ryegrass-white clover and tall fescue pastures rotationally grazed through 26 paddocks. Soils were a mix of alluvial, peaty and humic silt loams across the farm, ranging from well to poorly drained. Paddocks were arranged in 26 replicate pairs, with each pair consisting of 0.5 ha per treatment. Annual rainfall at the site averaged 1250 mm.

Table 1: *Summary of the P21 Waikato dairy farmlet treatments imposed during 2011-2016.*

Management options	Current	Future
Area (ha),cows	13, 42	13, 34
Stocking rate (cows/ha)	3.2	2.6
N fertiliser (kg N/ha/year)	137	52
Dairy effluent (% farm, kg N/ha)	23, 9	50, 19
Cow BW, PW*	90, 75	170, 240
Cow liveweight (kg)	500	480
Replacements (%)	21	18
Stand-off, duration-controlled grazing	None	Mar-Jul
Grain purchased (kg DM/cow)	0	Up to 400

*BW=Breeding Worth, PW=Production Worth, as selected in May 2011.

Measurements

Various productivity parameters were monitored, including animal health, milk yield and composition, feed intake and composition (Roach et al. 2016). From these measurements, pasture and supplement dry matter, and N intakes were calculated for each farmlet. Estimates of N leaching were calculated from measurements of nitrate concentrations determined on soil water samples collected from 16 porous ceramic cups installed at 60 cm depth in each paddock, and multiplied by the drainage flux calculated using a soil water balance. Thus, N leaching data for each farmlet are based on results from a total of 416 suction cup samplers (26 paddocks x 16 samplers per paddock). Two novel methods for measuring urinary N output, urine sensors and 'urine spotting' (Shepherd et al. 2017), were compared with a herd N balance calculation to estimate differences in urinary N excretion between farmlets. N leaching data from individual years (26 replicates per treatment) were analysed for statistical significance ($P < 0.05$) using analysis of variance (ANOVA) using Genstat and R statistical software.

Results

Measured nitrate leaching

Nitrate leaching losses varied widely between years, reflecting substantial differences in weather (and thus drainage) conditions (Fig.1). N leaching losses were consistently lower in the Future farmlet. On average, N leaching losses were reduced from 54 kg N/ha in the Current farmlet to 31 kg N/ha in the Future farmlet, which corresponded to a reduction of 43%.

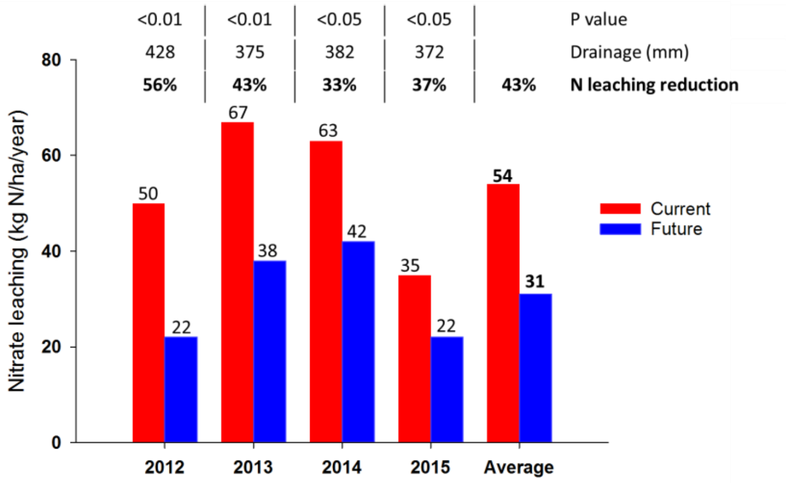

Figure 1: *Annual nitrate-N leaching losses in the P21 Waikato Current and Future farmlets, from 2012-2016.*

How N leaching reductions were achieved

Analysis to-date of measured and modelled data suggests the two strategies of reducing N inputs and capturing urine in autumn each contributed about half of the N leaching reduction achieved over four years of measurement.

1. ***Reducing N inputs***

Reducing N fertiliser inputs from 137 kg N/ha in the Current farmlet to 52 kg N/ha in the Future farmlet (-62%) corresponded to a reduction of 16.9 to 15.4 t DM/ha/year (-9%) in pasture grown. This was predictable hence a lower cow stocking rate, from 3.2 to 2.6 cows/ha, was used in the Future farmlet (-19%). These changes resulted in a reduction in N intake by the herds (pasture and supplement) of 540 to 462 kg N/ha/year (-15%) in the Current and Future farmlets, respectively. Based on the combined results of three methods for estimating urinary N output, approximately 19% less urinary N was excreted per hectare (Shepherd et al. 2016).

2. ***Capturing urine***

The key risk period for the source of urinary N leached from the farmlets was deemed to be from late summer until early winter (Shepherd et al. 2011). Use of the stand-off pad was, therefore, scheduled from March (c.8 hours/day) to July (up to 15 hours/day) to remove cows from pasture (Figure 2) (Roach et al. 2016). Supplement fed was approximately 10% of N intake in both herds. The effluent-treated area of the Future farmlet was increased from 23 to 50% of farm area to account for the greater amounts of effluent nutrients captured in the stand-off pad. This effluent was returned to pasture during the relatively low risk period of spring.

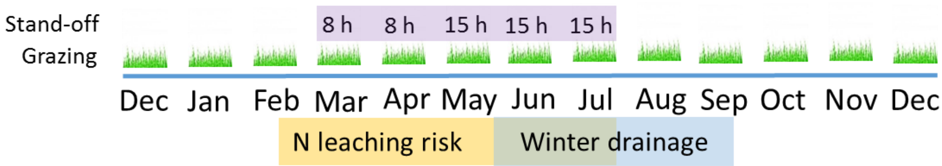

Figure 2: *Timing of stand-off pad use on the Future farmlet, 2012-2016. Usage was scheduled to align with the corresponding risk period of N leaching.*

Lessons learnt

- Urinary N output is the key parameter driving risk of N leachingin the grazed pasture system. Research methods developed in this programme have provided accurate, relevant and useful data to explain the underpinning drivers for differences in N leaching losses between systems (Shepherd et al. 2016; 2017).
- The full results show small reductions in milk production and profitability for the Future farmlet (Glassey et al. 2014; Roach et al. 2016). The main driver for the decline in profit was the capital cost of the stand-off infrastructure.
- Farm systems models (OVERSEER, APSIM, Whole Farm Model) were used throughout the study to design the farmlets, inform tactical decision-making and estimate N transfers and leaching loss. Models generally performed well, consistently capturing the treatment effect on N leaching loss (Future < Current). Models were, however, unable to describe N leaching accurately in individual years. Pre-experimental modelling predicted N leaching would be reduced by 40% (59 to 35 kg N/ha), which was similar to the 4-year measurement average of 43% (54 to 31 kg N/ha).
- Tools are already available for farmers to adopt the ‘low input’ system (Pellow, 2017), although a sound knowledge and application of good pasture and grazing management practices are required.
- Similar results were observed in other dairy farmlet comparisons undertaken in this and other regions where the same principles of N management were evaluated (Shepherd et al. 2017, Chapman et al. 2017).

Conclusions

Nitrate leaching was reduced by an average of 43% per year (23 kg N/ha) in a ‘Future’ dairy system compared with a ‘Current’ system. This reduction was achieved equally through two strategies:

1. Reducing N fertiliser inputs resulting in less pasture grown which was eaten by fewer cows, and
2. Reducing urinary N returns to pastures by standing cows off pasture 8-15 hours per day from March to July.

Both strategies reduced the amount of urinary N deposited to pastoral soils preceding (Feb-July) and during the main period of N leaching risk in the Waikato (Jun-Sept). Milk production was broadly similar between the two systems, whereas preliminary data indicate there was a small reduction in profitability in the Future compared to the Current farmlet, driven primarily by the capital cost of the stand-off infrastructure.

These results highlight the importance of good grazing management, such that stocking rate matches feed supply (not visa versa), and cows are removed from pasture in key N leaching risk periods. The two strategies can be implemented separately or together depending on individual farm system attributes and the environmental goals that are sought.

Acknowledgements

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