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NUTRIENT LEACHING UNDER INTENSIVE SHEEP GRAZING: A NEW RESEARCH INITIATIVE

Sarmini Maheswaran*, Lydia Cranston, James Millner, David Horne, James Hanly, Paul Kenyon, and Peter Kemp

School of Agriculture & Environment, Massey University Private Bag 11 222, Palmerston North 4442, New Zealand

*Email: *s.navarathnam@massey.ac.nz*

Abstract

Many New Zealand sheep farmers are attempting to increase forage production, stock performance and profitability. These intensive sheep systems are likely to result in greater nutrient losses in drainage. However, the choice of forage species may help to minimise or mitigate some of these nutrient losses. A systems scale, long-term field trial, which includes 20 drainage plots (40 m x 20 m each), is currently being carried out at Massy University's Keeble farm to investigate the effects of forage species on feed grown, stock performance, profitability and the quantity of nitrogen (N) lost in drainage water. The soil type on the farmlets and plots is Tokomaru silt loam. Each plot is drained by a mole and pipe drainage system, which facilitates the monitoring of drainage volumes and the collection of drainage samples for analysis. The four forage types (treatments) on the plots are; perennial ryegrass/white clover, plantain/white clover, Italian ryegrass/white clover and a turnip/swede rotation. Other parameters being measured include phosphorus (P) loss, pasture accumulation, estimated ewe intake and ewe performances. Initial results, from the last part of the 2019 drainage season, suggest that leaching losses under sheep on this soil type are relatively small and that the use of alternative forage species may be an effective strategy for reducing the transfer of N from sheep farms to surface waters. The knowledge gained from this study will contribute to a better understanding of how sheep systems can achieve both improved productivity and environmental performance.

Introduction

The sheep industry makes a significant contribution to the New Zealand economy (Morris and Kenyon, 2014). However, increasing concerns about both environmental sustainability and farm profitability means that many sheep farmers have to consider adverse environmental effects of their systems, particularly the leaching of nitrogen (N) into waterways, while striving to increase productivity (Morris and Kenyon, 2014). The deposition of sheep urine significantly influences the N cycle in grazed pasture (Williams *et al*., 1990). The surplus N from urine patches is susceptible to leaching when drainage occurs (Field *et al*, 1985). Leaching of N from sheep farms has been studied in New Zealand (Field *et al*., 1985; Ruz-Jerez *et al*., 1995; Betteridge *et al*., 2010, Hoogendoorn *et al*., 2010; Hoogendoorn *et al*., 2011), and while N leaching under sheep is widely believed to be relatively small, compared to dairy cows, there have been no recent studies of N leaching under sheep at higher stocking rates. In addition, currently there are few options available to mitigate N leaching from sheep farming systems. Some of the practices used to reduce N leaching in dairy systems, for example housing, are not practical or cost-effective options for sheep farming (Morris and Kenyon, 2014).

The use of alternative forage species, as a relatively inexpensive means to minimise or mitigate N leaching from pastoral systems, is gaining increasing interest and research attention. There is evidence indicating that grazing cows on plantain, rather than perennial ryegrass, can help to mitigate nitrogen losses as a result of reducing the amount and/or concentration of urinary N excreted (Totty *et al*., 2013; Box *et al*., 2017; Navarrete *et al*., 2018). Other mitigation strategies include the use of winter active forages, such as Italian ryegrass, which have greater N uptake in winter and, therefore, reduced N leaching (Woods *et al*., 2016). Other forage options, such as brassica crops (e.g. swedes and kale), have the advantage that they produce large quantities of forage and, therefore, can help increase productivity but can result in higher rates of N leaching.

In New Zealand, little is known about the potential use and the efficiency of alternative plant species to reduce N leaching and/or increase production on sheep farms. Therefore, this research aims to explore the potential of alternative forage types to improve both the productivity and environmental efficiency of sheep systems. Specific objectives include; to determine N leaching under a range of forage types in a sheep grazing system, and to compare total and seasonal forage production and sheep performance in systems that incorporate alternative forages.

Methods

Trial site and treatments

Four farmlets were established on Massey University's Keeble farm, 5 km southeast of Palmerston North, Manawatu, New Zealand (40°24'02.0"S 175°35'52.8"E) in summer 2019. Each farmlet is 2.92 ha carrying 15 ewes/ha. Each farmlet has approximately 2.5 ha of perennial ryegrass and white clover pasture and 0.4 ha of an alternative forage. The three alternative forage types (treatments) studied here are: plantain/white clover, Italian ryegrass/white clover and a brassica (turnip/swede rotation). One of the farmlets has only perennial ryegrass/white clover pasture and so acts as the control. The soil type is Tokomaru silt loam. Twenty drainage plots were established on one of the paddocks (i.e. the four treatments were replicated five times) (Figure 1). Each drainage plot (800 m^2/plot) has an isolated mole drainage system, which facilitates the measurement of drainage flow rate, the collection of drainage samples and, thereby, the assessment of N leaching (Figure 2).

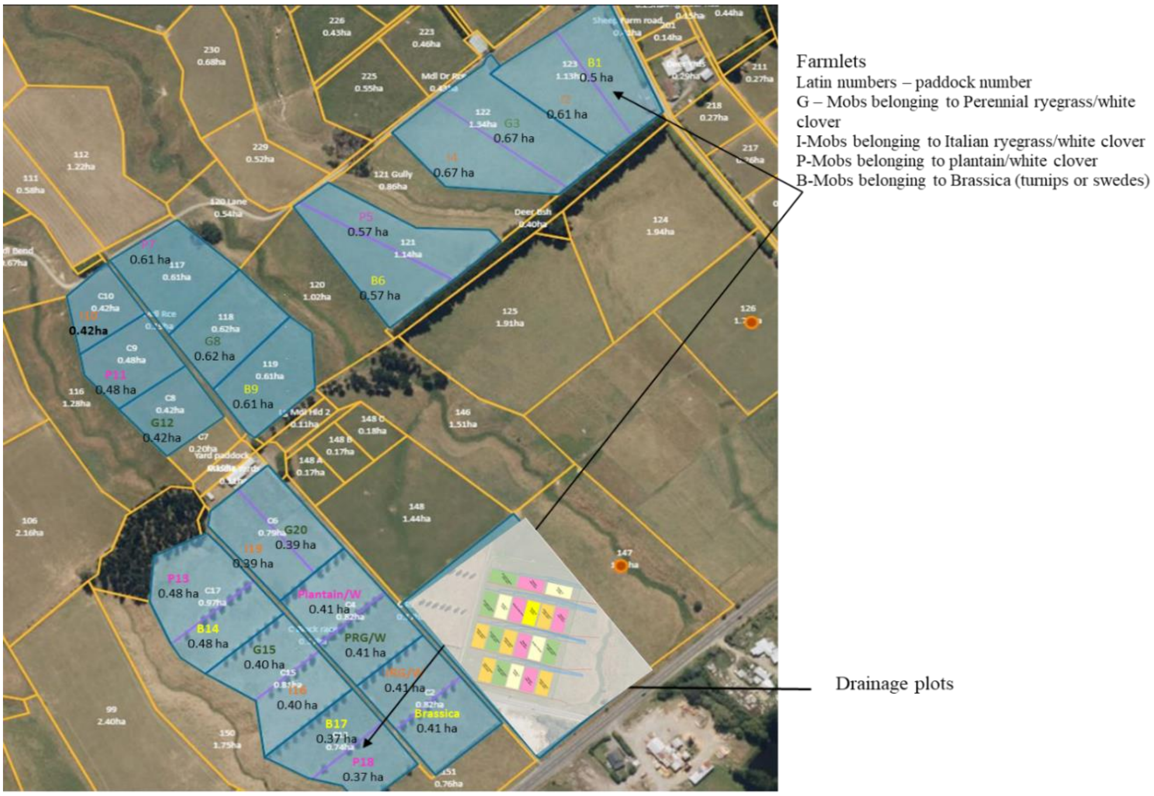

Figure 1: Layout of the farmlets and drainage plots

Figure 2: Individual tipping buckets and collection area for drainage water

Ewe management

A total of 184 pregnant mixed-age Romney ewes were selected from Keeble farm. The selected ewes were stratified by live weight and foetal number (single/twin/triplet) and allocated into four pasture treatment groups (n=46) based on ultrasound pregnancy scanning data. Each mob of ewes is rotationally grazed within their farmlet, with the duration of grazing and interval between farmlets adjusted for pasture growth rate and cover, which are assessed visually. Before ewes graze the drainage plots, they graze the treatment forage on their farmlet for approximately 1 to 4 days, so as to adapt them to the treatment forage before they graze the drainage plots. When the ewes were on the drainage plots, each mob was separated into five mobs to enable grazing of all five replicates at once (approximately 9 ewes/replicate plot mob). The number of grazing days and dates when the drainage plots were grazed was dependant on herbage mass and growth (Table 1).

Table 1: Grazing dates of ewes on drainage plots (between July 2019 and November 2019).

Grazing period	Grazing date	Grazing Plots
Winter 2019		
August	02 August to 13th August	Perennial ryegrass/white clover Italian ryegrass/white clover Turnips
Spring 2019		
September	19th September to 23rd September	Perennial ryegrass/white clover Italian ryegrass/white clover Plantain/white clover
October	24th October to 28th October	Plantain/white clover
	24th October to 30th October	Perennial ryegrass/white clover Italian ryegrass/white clover

Drainage water volume measurements and water analysis

Drainage water flow rate from each plot is measured using a tipping-bucket flow meter located in a sampling pit nearby. Each tipping-bucket was calibrated dynamically to account for higher tip volumes at higher flow rates. All tipping buckets were instrumented with data loggers to provide continuous measurements of flow rate. A small sub-sample (~0.1%) of the drainage water from every second tip of the tipping bucket flow meter was automatically collected to provide a representative sample for water quality analysis. Drainage water samples were filtered through a 0.45 µm filter and the filtrate analysed for nitrate and ammonium, using a Technicon Auto Analyser (Blakemore *et al*. 1987). Monitoring of drainage water and initial nitrate leaching commenced in the later part of the drainage season (July to November 2019) in the establishment year.

Results and dicussion

As expected, the amount of drainage from all the plots was reasonably consistent with totals for the later part of the drainage season of 109 mm, 108 mm, 112 mm and 99 mm for perennial ryegrass/white clover, plantain white clover, Italian ryegrass/white clover and turnips, respectively. The nitrate-N concentrations in drainage from all four treatments were low between July and November 2019 (Figure 3) with average concentrations of 0.41, 0.23, 0.40 and 0.25 mg N/L for the perennial ryegrass/white clover, plantain/white clover, Italian ryegrass/white clover and turnips treatments, respectively.

The majority of leaching losses under grazed pasture on this soil type tend to occur in the early drainage events (i.e. the first 100 mm or so of drainage), and drainage events in the later part of the season tend to have low N concentrations (Figure 3). The very small leaching losses reported here appear to conform to this pattern. Other researchers often note that differences in leaching rates between treatments imposed on pastoral farms on this soil are observed in early drainage events and tend to be less apparent in later drainage events. A simple soil water balance showed that there had already been approximately 200 mm of drainage before monitoring commenced at this new research site. Consequently, it is difficult to confidently draw any inferences about either N losses in drainage under sheep grazing or between N leaching under the four forage types. With the appropriate caution, it is suggested that the N losses under sheep grazing measured at this time of the year are very small and possibly smaller than leaching under dairy cows.

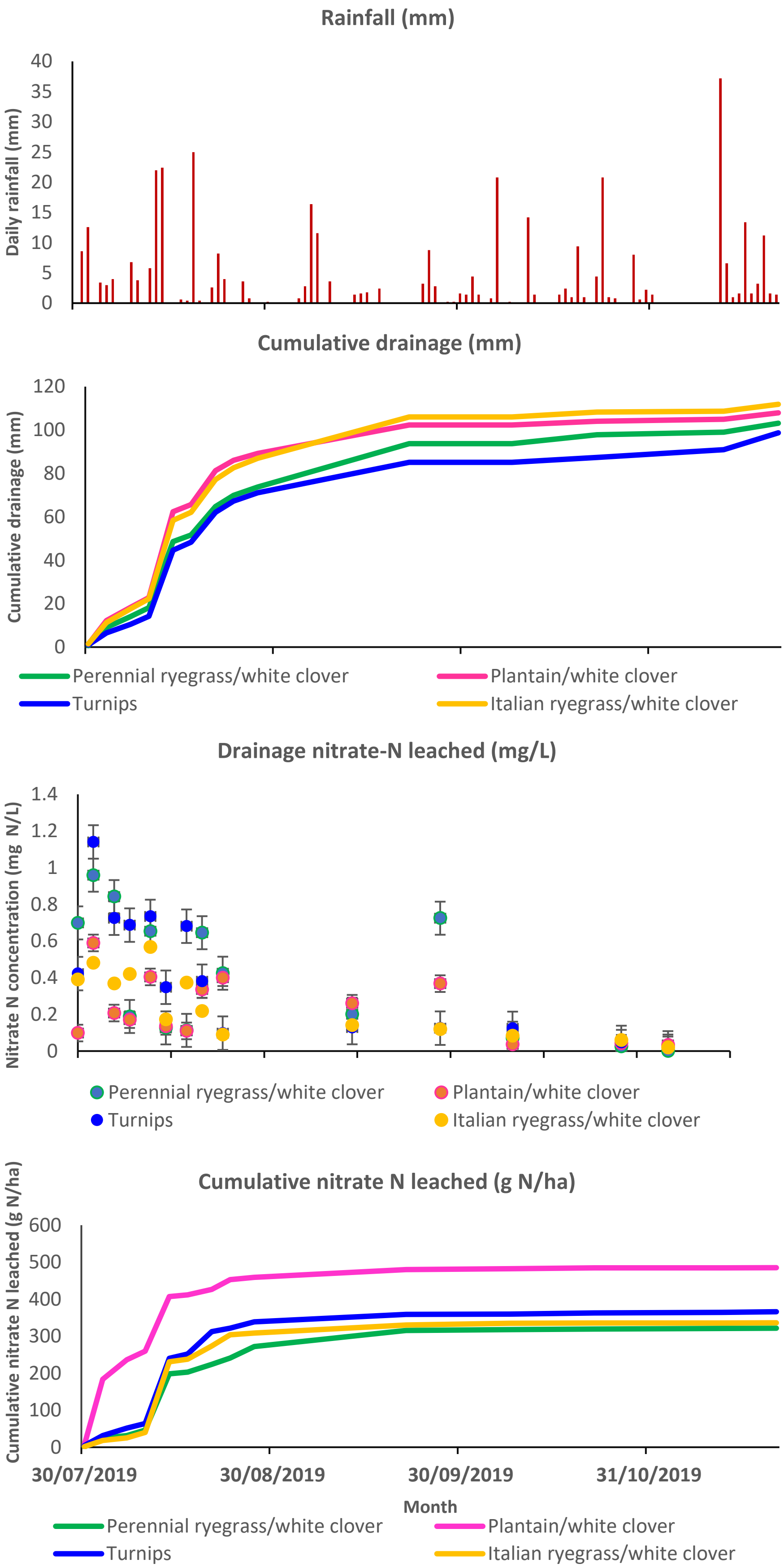

Figure 3: Rainfall (mm), cumulative drainage (mm), nitrate-N concentration (mg N/L) in drainage water, and cumulative nitrate-N leached (g N/ha) in drainage water for pasture treatments between July and November 2019.

The Future

The trial will continue until December 2021. At completion, this study will provide farmers with information that may help them improve environmental performance while maintaining or improving productivity.

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