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DOES GIBBERELLIC ACID REDUCE NITRATE LEACHING LOSSES FROM ANIMAL URINE PATCHES?

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Abstract

In New Zealand, the urine deposited by dairy cows onto the paddock while grazing year-round represents an input of nitrogen (N) into the soil-plant system greater than the amount the plants can use. The nitrogen which is not taken up by the pasture is often lost from the soil in drainage water. For this reason, N leaching is a significant environmental concern in intensively grazed NZ pasture-based systems.

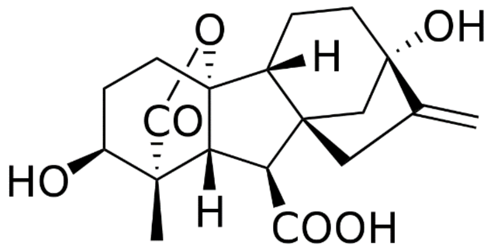
One mitigation approach could be to apply gibberellic acid (GA) to increase the uptake of N by pasture, particularly during the cooler seasons where risk of leaching is high. GA is a plant hormone which occurs naturally in most plants and is responsible for stem elongation and leaf expansion. It is currently used by some farmers to stimulate dry matter (DM) production under rotational grazing when cool soil temperatures limit natural pasture growth rates. We hypothesized that application of GA to pasture in the autumn would increase pasture growth and uptake of urinary N during this time, and subsequently reduce N leaching loss.

A lysimeter study was conducted to measure pasture growth, N uptake, and N loss to water beneath pasture urine patches treated with, and without, GA. Results showed there was no significant difference in annual pasture DM yield, N uptake or N leaching loss between the urine + GA treated lysimeters compared with the urine-only lysimeters. These results suggest that, at the urinary N rate of 700 kg N ha^{-1} used in this trial, an application of GA would not reduce N leaching loss. However, pasture treated with N fertiliser (50 kg N ha^{-1}) has previously been shown to have an additive DM response to a GA application. Therefore future research could determine the GA response rate when applied to lower rates of urine-N to investigate whether a reduction in N leaching loss would occur.

Introduction

New Zealand dairy systems are typically pasture-based where cattle graze outdoors year-round. The urine deposited by dairy cows onto the paddock while grazing represents an input of nitrogen into the soil-plant system greater than what the plants can use. The nitrogen which is not taken up by the pasture is often lost from the soil in drainage water (Cameron *et al.*, 2013). The leached N can contaminate ground and surface waters causing a decline in water quality. For these reasons, N leaching is a significant environmental concern in intensively grazed NZ pasture-based systems. One mitigation approach could be to apply gibberellic acid to increase the uptake of nitrogen by pasture, particularly during the cooler seasons where risk of leaching is high.

Gibberellic acid is a plant hormone which is responsible for stem elongation and leaf expansion in plants. It has been shown to increase pasture dry matter production in the shoulders of the season when cool temperatures limit plant growth. This extra growth when the pasture plants would otherwise be growing very slowly could potentially increase the uptake of urine deposited N. While, some studies have shown increased pasture N uptake and crude protein (CP) content following an application of GA (Morgan & Mees, 1958; Finn & Nielsen, 1959; Biddiscombe *et al.*, 1962), others reported reduced N and CP levels (Scurfield, 1958; McGrath & Murphy, 1976; Percival, 1980). Parsons *et al.* (2013) suggested that gibberellic acid may be useful for reducing environmental impacts such as nitrate leaching, but no studies have actually measured this. This knowledge gap presents an opportunity to improve our knowledge and understanding of the effect of GA on the soil-plant system, and determine whether GA has any further environmental benefits. Therefore it was hypothesized that the application of GA to pasture in the autumn would increase pasture growth and uptake of urinary N during this time, and subsequently reduce N leaching loss.



Gibberellic acid

Methods

A trial was conducted using 0.5 m diameter, 0.7 m deep lysimeters. Soil type was a Templeton sandy loam. Treatments are outlined in Table 1. Urine was applied at a rate of 700 kg N ha^{-1} in early May 2014, and GA was applied at 8 g GA ha^{-1}, at the same time.

Table 1 Lysimeter treatments.

Species	Treatment	Replication
Perennial ryegrass + white clover	Urine	5
Perennial ryegrass + white clover	Urine + GA	5

Analysis

Chemical analyses was carried out on leachate, pasture and soil samples for this study. For leachate samples, the total drainage volume was recorded on each sampling occasion, and NO_3^--N, and NH_4^+-N concentrations determined by flow injection analysis (FIA). ^{15}N enrichment of the leachate was also analysed however this data is not presented here. At each harvest date, pasture was cut to 50 mm, and oven-dried (60 ^{o}C, 48 hrs) to determine pasture dry matter yields. Dried pasture was ground and then analysed for total N using an Elementar Vario-Max CN Elemental Analyser. ^{15}N enrichment and pasture quality parameters were also determined, however this data is not presented here. Soil samples were collected at the end of the experimental period at four different depths. These were analysed for inorganic N via KCl extraction and FIA, and total N and ^{15}N enrichment were determined by IRMS. Soil data is not presented here.

Photos: Left - Lysimeter set-up. Centre - Urine treatment application. Right - Pasture harvest using electric clippers.

Results

The total N leaching losses over the experimental period were not significantly different between the lysimeters treated with GA + Urine, compared with those which just received urine (P = 0.189) (Figure 1).

Similarly, total pasture DM yield harvested over the experimental period and N uptake were also not significantly different between the GA + Urine and Urine only treatments (P = 0.705) and (P = 0.925), respectively (Figure 2a, b).

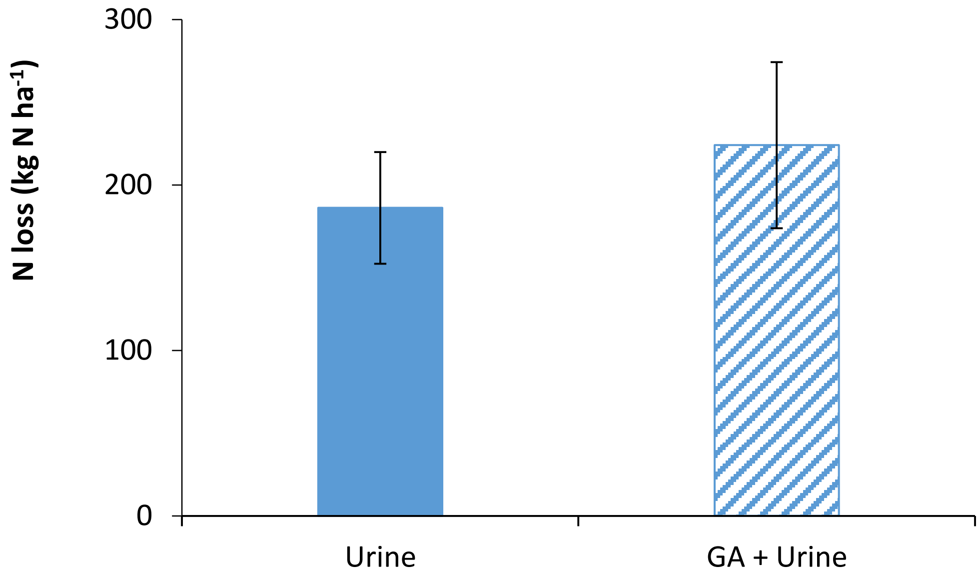
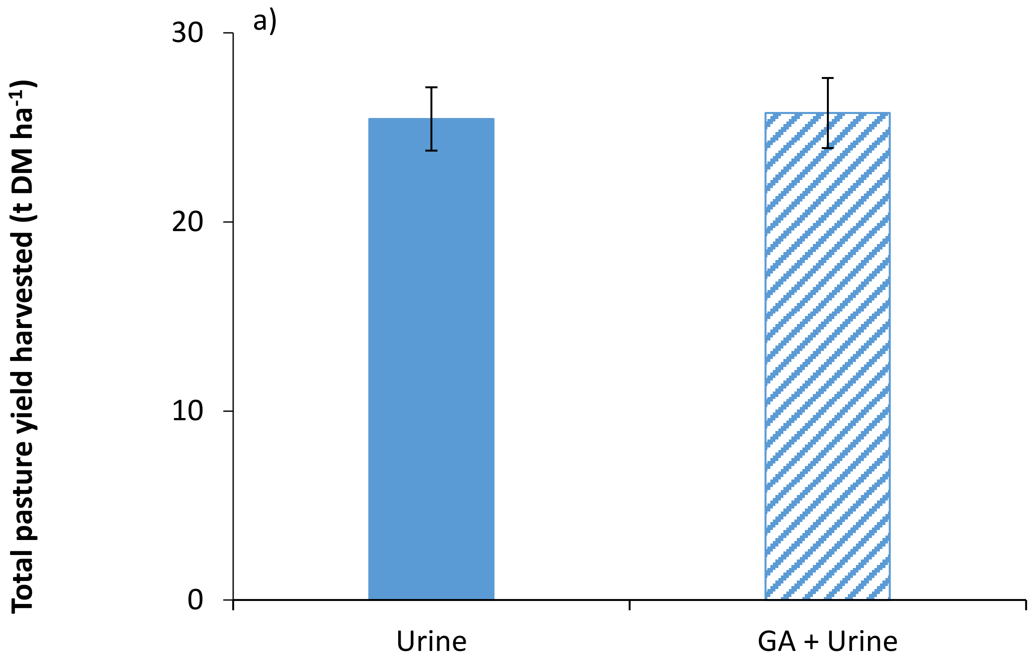


Figure 1 Total nitrogen leaching loss (mineral NO_3^--N and NH_4^+-N) (kg N ha^{-1}) from lysimeters for the experimental period: 7 May 2014 to 1 October 2015.



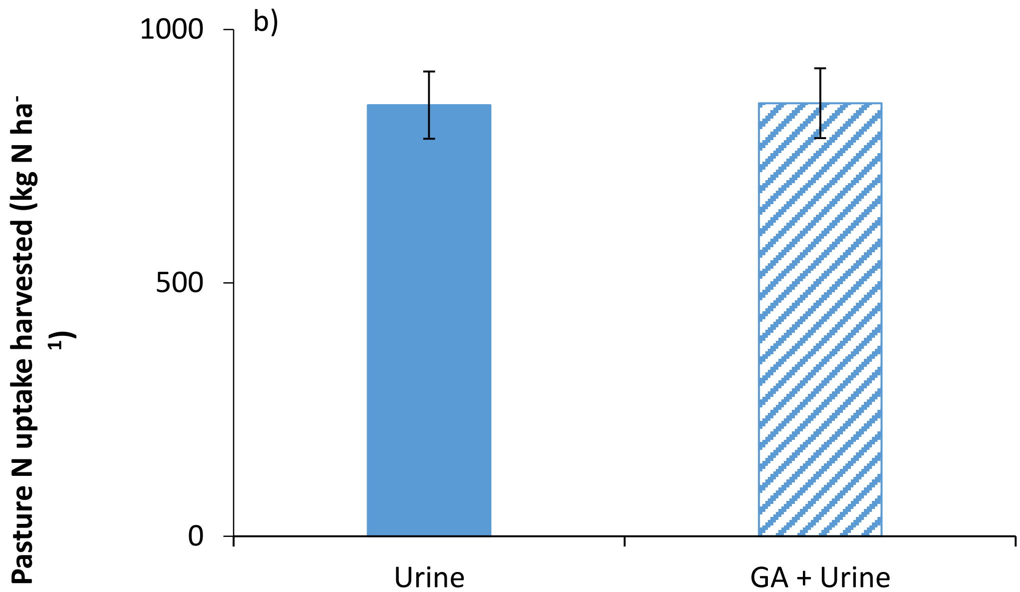


Figure 2 Pasture a) total dry matter yield harvested (t DM ha^{-1}) and b) nitrogen uptake harvested (kg N ha^{-1}) from lysimeters for the experimental period: 7 May 2014 to 1 October 2015.

Conclusions

- The results from this trial suggest that, at the urinary N rate of 700 kg N ha^{-1} used, an application of GA would not reduce N leaching loss.
- Further research is ongoing to determine the GA response rate when applied to lower rates of urine-N to investigate whether a reduction in N leaching loss would occur.

Acknowledgements
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