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HORSES, GRAZING AND NITROGEN IN SOILS

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Abstract

Horses managed on pasture are often in paddocks with low pasture covers, where two distinctive areas become evident: preferential grazing occurs in the lawns (estimated 70% of the pasture area), while urination and defecation occur in the latrines or roughs (the remaining 30%). There is no data in New Zealand on the loading or leaching patterns of nitrogen (N) across the latrine and lawn areas, or in comparison with other grazing systems. The aim of the present work was to provide some insights into the differences in soil, pasture and leachate N concentrations between latrines and lawns in paddocks frequently grazed by horses.

Soil cores and pasture samples were obtained in February 2021, from the lawn and latrine areas in 3 paddocks, located on different terraces with contrasting soil types, from fine textured loessal soil (Tokomaru silt loam) to intermediate (Manawatu silt loam) and coarse textured (Manawatu fine sandy loam) alluvial soils. Additionally, water samples were extracted via suction cups (24-hour collection) at 3 times from August to October 2021, from 2 areas of latrines and lawns in the paddock with Manawatu fine sandy loam soil.

Total N content in the soil in the roughs was twice the content in lawns (19.16 ± 11.69 vs 10.51 ± 2.83 N mg/kg DM soil). The greatest differences appeared in the first 7.5 cm of soil, where nitrate concentration was almost 3 times greater in roughs compared with lawns (25.07 ± 10.32 vs 8.50 ± 3.90 NO_3^--N mg/kg soil). Pasture cover was greater in the roughs compared with lawns (3126 ± 2594 vs 1283 ± 854 kg DM/ha). No differences were found in the dry matter, metabolizable energy and crude protein content between pasture from lawns and roughs. Drainage water under the roughs had 7 times greater concentration of nitrate compared with samples obtained under the lawns (8.32 ± 13.21 vs 1.18 ± 2.25 NO_3^--N g/m^3). Nitrate concentrations in drainage under the roughs were variable.

In conclusion, horses' grazing and excreting behaviour affected the N leaching pattern by modifying the N loading rate in the roughs (latrines). It is unclear if this modified pattern of N loading will increase N leaching on a whole-paddock or farm basis. A greater understanding of leaching patterns from equine farms is needed for the identification of mitigation options and nutrient management plans.

Introduction

Horses are selective grazers and their grazing behaviour generates areas of "lawns" where preferential grazing occurs, and areas of "roughs" (or latrines) where horses urinate and defecate. This selective grazing results in approximately 70% utilization of the pasture on offer, which reflects the relative area of lawns (preferential grazing areas) whilst the roughs are mostly rejected (Adams et al., 2021; Rogers et al., 2017). Under intensive management, horses can eat to very low pasture covers, and this provides a contrast to the longer (rank) grass observed in the latrine areas. The latrine areas are rejected by horses but can often be consumed by co-grazing with ruminants, which not only improves pasture utilisation but maintains pasture quality (Rogers et al., 2017).

The proportion of 70% lawns to 30% roughs appears consistent across different equine livestock classes and production systems (Rogers et al., 2017). This unequal distribution of urine and faecal material within the total pasture area may alter the relative loading of nutrients and potential for nitrogen (N) leaching, particularly during periods of high stocking density, such as the breeding season from September to December (Rogers et al., 2016). Studies in other countries have shown that horse paddocks pose a potential threat to water quality via leaching of excess P and N, particularly in feeding and excretion areas on sandy soils (Parvage et al., 2015). However, there is no data on the relative loading and N leaching potential within the rough and lawn areas, or in comparison with other grazing systems in New Zealand. This information is needed to improve estimations of N losses in equine properties for the future development of nutrient management plans to meet obligations set by regional councils.

Therefore, the objective of this pilot study was to provide insights into the differences in soil, pasture and leachate N concentrations between roughs and lawns in paddocks frequently grazed by horses.

Materials and methods

This study was conducted in 2021 at the Veterinary Large Animal Teaching Unit farm (Massey University, Palmerston North). The paddocks selected for the study had a history of being frequently grazed by 3 groups of horses (n=7, 8, & 9 horses in each group), with a total of 24 adult horses (14 mares and 10 geldings) and a mean bodyweight of 537 (± 56) kg (Adams et al., 2021). Each cohort of horses was set stocked on the pasture for grazing periods of 2-10 weeks throughout the year. The management system reflected the management system of recreational horses in New Zealand. Areas of lawns and roughs (latrines) were clearly evident, and transects in both areas were mapped based on GPS coordinates. Paddocks were occasionally cross grazed with sheep and cattle.

Estimation of nutrient loading

Nitrogen loading was estimated based on deterministic modelling for adult horses presented by Chin et al. (Chin et al., 2019). The model assumes that a horse of 560 kg of bodyweight (BW) has a voluntary feed intake of 2% BW, and will require 706 g CP/day (113 g N) for maintenance. Both N intake and excretion are a function of the CP content of the feed. All of the CP required was sourced from pasture only, and pastures for equine production in New Zealand typically have 22% CP. The standard stocking rate from previous studies on this farm was 4 horses per hectare (Adams et al., 2021), and the CP content of the measured pasture (refer to Measurements section) was also used in the calculations.

Measurements

Soil samples

Soil cores (n = 36) were obtained in February 2021 from a section of lawn and a section of latrine (6 cores to 15 cm depth in each area) within the 3 monitored paddocks. The paddocks were located on different terraces with contrasting soil types, from fine textured loessal soil (Tokomaru silt loam) to intermediate (Manawatu silt loam) and coarse textured (Manawatu fine sandy loam) alluvial soils. The core samples were cut in half to obtain two depths (0 - 7.5 cm and 7.5 - 15 cm) and grouped per area and paddock for laboratory analyses. Samples were analysed at the Massey University Soil Laboratory (Palmerston North, New Zealand). The content of moisture, nitrate (NO_3), ammonia (NH_4) and total mineral N were measured.

Pasture samples

Pasture cuts (n=6) were obtained in February 2021 from the same sections of lawn and latrines in the 3 paddocks of the farm. Samples were assessed for botanical composition using previously described methods (Bengtsson et al., 2018), and the remaining unsorted pasture was also dried to obtain pasture dry matter (DM) content and total cover (total pasture mass kg DM/ha= dry weight * 55.55). Dried pasture samples were then sent for nutritional analysis to the Massey University Nutrition Laboratory (Palmerston North, New Zealand). The levels of ash, crude protein (CP), lipid, neutral detergent fibre (NDF), acid detergent fibre (ADF), organic matter digestibility (OMD), metabolizable energy (ME) and SSS (starch and soluble sugars) were estimated by near infrared reflectance (NIR) spectrometry.

Groundwater samples

Groundwater samples (n = 40) were extracted via suction cups (24-hour collection) during August (n = 11), September (n = 15) and October (n = 14) 2021, from 2 areas of latrines and lawns in the paddock with Manawatu fine sandy loam soil. Samples were frozen and sent to Central Environmental Laboratories (Palmerston North, New Zealand). Drainage water samples were filtered through a 0.45 µm filter and the dissolved fraction was analysed for levels of nitrates (detection limit 0.005 g/m^3 NO_3^--N), following the APHA 23rd Ed. 4110 B methodology.

Statistical analysis

Data were analysed using the PROC MEANS procedure of SAS 9.4 (SAS Institute, 2009).

Results and discussion

Estimates of N intake and excretion (urine plus faeces) for horses at different levels of CP in pasture are presented in Table 1. Assuming a stocking rate of 4 horses per hectare, the estimated potential loading of N was 0.552 kg N/ha, but given that the excretion only occurs in the roughs, the potential loading increased to 1.84 kg N/ha in the roughs in February 2021. This value could be 3.75 kg N/ha for a typical equine production system on better pastoral land.

Table 1. Nitrogen loading estimates, based on a deterministic modelling for adult horses (Chin et al., 2019), and at different levels of crude protein in pasture.

Variable	1 horse		4 horses (/ha)	
Bodyweight (kg)	560		2240	
Voluntary feed consumption (kg DM/day)	11.2		44.8	
Pasture crude protein	14%	22%	14%	22%
N intake (kg/day)	0.251	0.394	1.004	1.576
N excretion (kg/day)	0.138	0.281	0.552	1.125
- Per kg of Bodyweight	0.0002	0.0005		
- Per hectare in roughs (30% area)			1.84	3.75

Soil and leachate N content, as well as pasture cover and quality results, are presented in Table 2. Total N content in the soil under the roughs was twice the content of the lawns across the 3 paddocks. Similar results were reported in other countries, with very different climate and management systems (Parvage et al., 2013). The greatest differences appeared in the first 7.5 cm of soil, where nitrate concentration was almost 3 times greater in the roughs compared with the lawns (25.07 ± 10.32 vs 8.50 ± 3.90 NO_3^--N mg/kg soil, Table 3). At greater depths, the difference between lawns and roughs was smaller.

Total N, nitrates and ammonia were always higher in the first 7.5 cm compared with the deeper part of the cores (Table 3), within lawns (52% greater total N) and within latrines (180% greater total N). This was expected given the timing of soil coring, i.e. the soil was dry and so there would be little movement of urine to greater depths.

Table 2. Mean value (±SD) for soil and leachate Nitrogen content, and pasture cover and quality results.

Variable	Units	n	Lawn	Rough
Soil				
NO_3^-	(mg/kg)	12	7.05 ± 3.04	17.28 ± 10.76
NH_4^+	(mg/kg)	12	3.46 ± 2.04	1.88 ± 1.77
Total N	(mg/kg)	12	10.51 ± 2.83	19.16 ± 11.69
Pasture				
Cover	(kgDM/ha)	6	1283 ± 854	3126 ± 2594
%DM	(g/100g)	6	0.33 ± 0.03	0.35 ± 0.06
ME	(MJ/kg DM)	6	9.10 ± 0.56	8.71 ± 0.55
CP	(g/100g DM)	6	14.62 ± 2.2	13.93 ± 3.76
Leachate[§]				
NO_3^-	(g/m^3)	40	1.18 ± 2.25	8.32 ± 13.21

[§]Leachate samples were obtained from one of the three paddocks included in the study.

Table 3. Mean value (±SD) for soil Nitrogen content across the top 15 cm of the soil profile.

Area	Depth (cm)	Moisture (%DM)	NO_3^- (mg/kg)	NH_4^+ (mg/kg)	Total N (mg/kg)
Lawn	**Total**	**0.83 ± 0.03**	**7.05 ± 3.04**	**3.46 ± 2.04**	**10.51 ± 2.83**
	0-7.5	0.81 ± 0.02	8.50 ± 3.90	4.18 ± 2.83	12.68 ± 1.46
	7.5-15	0.86 ± 0.01	5.60 ± 1.25	2.75 ± 0.89	8.34 ± 1.94
Latrine	**Total**	**0.81 ± 0.04**	**17.28 ± 10.76**	**1.88 ± 1.77**	**19.16 ± 11.69**
	0-7.5	0.78 ± 0.03	25.07 ± 10.32	3.14 ± 1.58	28.22 ± 9.69
	7.5-15	0.84 ± 0.03	9.48 ± 0.64	0.61 ± 0.72	10.09 ± 1.10

Pasture cover across the 3 paddocks was greater in the roughs compared with the lawns (Table 2), which was explained by the greater nutrient concentration in the roughs, in combination with horses' grazing avoidance, greater post-grazing residual and consequently greater growth rates observed in the roughs compared with lawns (Adams et al., 2021). Pasture in the roughs consisted of 49% grasses, 2% clover, 48% dead matter and 2% weeds. Pasture in the lawns consisted of 49% grasses, 17% clover, 28% dead matter and 6% weeds. No differences were found in the dry matter, metabolizable energy and CP content between pasture from lawns and roughs. Overall, the values of energy and CP content were lower than values found in commercial equine pastures in summer (10.7 MJ ME/kg DM and 21.4 %CP (Rogers et al., 2020)).

The drainage water followed the same trend as the soil results, with drainage water under the roughs presenting 7 times greater concentration of nitrate compared with samples obtained under the lawns in 1 of the paddocks (Table 2 and Figure 1). The highest concentration of nitrates in the drainage water from the roughs is supported by equine studies in other countries, where the leachate concentrations and net release of P, N and dissolved organic C from paddock topsoil were highest in feeding and excretion areas (Parvage et al., 2015).

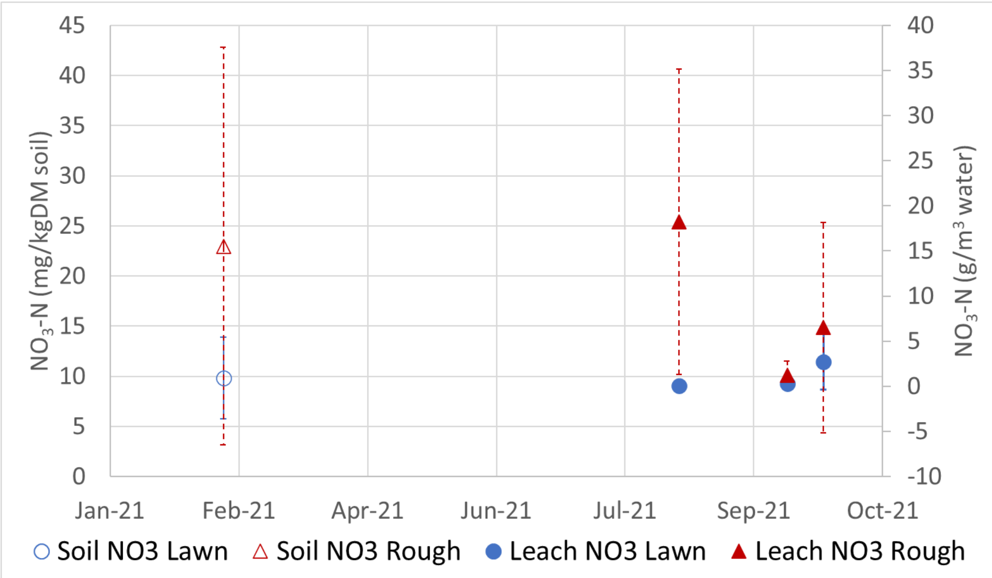

Figure 1. Mean Nitrate concentration in soil and drainage water - Manawatu fine sandy loam

Nitrate concentrations in the drainage water under the roughs seemed to decrease over time, although results were highly variable. The decreasing concentration of nitrates in drainage water has been seen in other studies. For example in dairy systems, the highest concentrations of nitrates in drainage water occurred typically during the first 50 to 100 mm of drainage, and consequently, the majority (>70%) of the NO_3-N leaching occurred relatively early in the drainage season, prior to August or the start of spring (Christensen et al., 2019). The results presented here, however, were from samples obtained in late winter and early spring (August to November) and thus it is not known if most of the nitrate present in the soil had already leached prior to obtaining the samples.

The paddocks included in the study were cross grazed with ruminants, and so it was expected an increase in the total N content in the soil and water leached, compared to paddocks grazed only by horses. However, given that ruminants graze and urinate-defecate around the paddock evenly, the increase in N content should have been of similar magnitude across lawns and roughs.

These preliminary results indicate that horses' grazing and excreting behaviour affect the N leaching pattern by modifying the N loading rate in the roughs. It is unclear as to whether this modified pattern of N loading will increase N leaching on a whole-paddock or farm basis, given the regular deposition of dung and urine at the same 30% of the area. This information should be considered when modelling farm level N excretion: for example, in future developments of Overseer. A greater understanding of leaching patterns from equine farms is also needed for the identification of mitigation options and nutrient management plans.

Conclusion

Horses' grazing and excreting behaviour affects the N leaching pattern by modifying the N loading rate in the roughs (latrines). It is unclear if this modified pattern of N loading will increase N leaching on a whole-paddock or farm basis. A greater understanding of leaching patterns from equine farms is needed for the identification of mitigation options and nutrient management plans.

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