Using Tropical Grasses to Enhance the Efficiency of Nitrogen Capture from Dairy Effluent

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Abstract

Five rates (0, 28.0, 65.4, 83.7 and 111.7 mm) of dairy effluent were applied through irrigation to tropical grass pasture during the wet season on the Atherton Tablelands in the Far North of Queensland, Australia. Irrigation water was applied to the treatments in inverse proportion to the effluent for equivalent total water application. Pastures were harvested on a three weekly basis, dry matter yield determined and sub samples analysed for N concentration (%), and Nitrogen yield (kg ha^{-1}) calculated. Lysimeters installed in the high effluent treatment and the no effluent treatment measured leachate volume to 50 cm. Samples of leachate were analysed for nitrogen concentration and loss below 50 cm calculated. There was no significant difference in pasture yield and nitrogen yield among treatments. Loss of nitrogen through leachate was substantial in both the high effluent treatment and the zero effluent treatment.

Media Summary

Applying dairy effluent to tropical grass pasture during the summer wet season did not produce significantly more pasture but resulted in greater leaching losses of nitrogen.

Key Words

dairy effluent, nitrogen, pasture yield, lysimeters, leaching

Introduction

The dairies of the Atherton Tablelands of northern Queensland use two effluent disposal strategies, either storage of all effluent in a single storage pond which is then sprayed onto pasture in the dry season (April to November); or, more commonly direct application twice daily after the bails are cleaned post milking. The second system has the risk of loss of nutrients (N) by run-off and leaching during the wet season (December to March) even though summer grasses (C4 species) such as (*Cyanodon sp.*) of any mixed pasture system have the highest capacity for nitrogen uptake and control of NO_3-N leaching compared with any other farming system (Woodward *et al*. 2000). This study examined the nitrogen uptake and leaching of N under this effluent disposal strategy during the summer wet season.

Methods

This research site was on the Queensland Department of Primary Industries Kairi Research Station (17°12',145° 34'), 700 m above sea level on the Atherton Tablelands in North Queensland. Average annual rainfall is 1289 mm (range 750 to 2500mm). The soil at the site is a free draining mesotrophic Red Ferrosol, Tolga (Malcolm *et al.,* 1999). Rainfall is predominately in the summer months from December to March (65 to 70 % of total rain). Annual pan evaporation is 1115 mm. Daily evapotranspiration during the summer period is usually about 5 mm/day.

Effluent application

The experimental area had permanent solid set irrigation installed with 15m between sprinklers and 18m between laterals on a triangular spacing (Figure 1). When constructed this system was designed to allow the irrigation of ponded dairy effluent. For this experiment taps were installed into each lateral. This allowed individual laterals to be opened or closed to allow different application times of effluent and water through each lateral line. The pasture was kikuyu (*Pennisetum clandestinim*) dominant, which had been sown to annual ryegrass (*Lolium multiflorum*) the previous autumn.

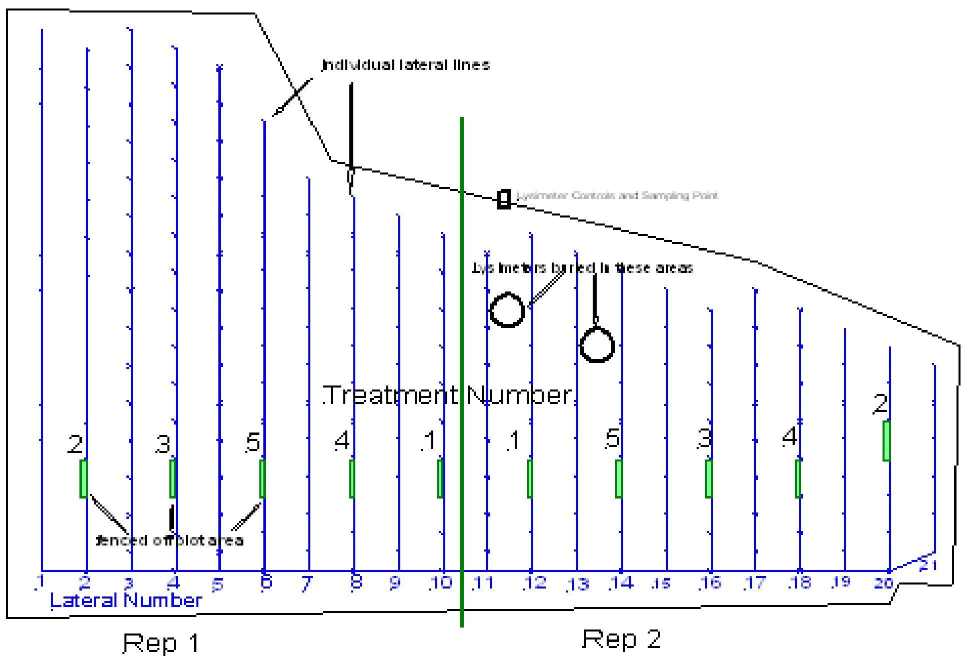

Figure 1: The layout of the trial site showing plot and lysimeter positions

Five treatments in two replications were established to receive 0, 6, 12, 18 or 24 mm of effluent at each application. Therefore, as Treatment 5 received 24 mm of effluent, Treatments 1, 2, 3 and 4 would receive 0, and approximately 25, 50 and 75 % of the amount of effluent applied to Treatment 5. The water deficit of the lower effluent treatments was made up by applying clean irrigation water.. The timing and amount of effluent applied during the experimental period was 0, 28.0, 65.4, 83.7 and 111.7 mm of effluent (Table 1) with a resultant 0, 21.4, 48.9, 64.9 and 86.3 kg N ha^{-1} being applied.

Table 1: Total amount of effluent and amount (mm) applied to each treatment at each application

Date	Treatment				
	T1	T2	T3	T4	T5
21Nov	0.0	5.6	9.8	21.8	26.3
7Dec	0.0	7.1	15.4	18.3	27.3
9Jan	0.0	4.8	17.2	14.7	19.8
16Jan	0.0	5.8	13.0	14.8	21.9

31Jan	0.0	4.7	10.0	14.0	16.5
Total	0.0	28.0	65.4	83.7	111.7

Lysimeter sampling

Six vacuum lysimeters were installed in the pasture on 9th May 2000 prior to the planting of annual ryegrass (*Lolium multiflorum*). Three lysimeters were placed in Treatments 1 and 5 in Replication 2. It was not feasible to install lysimeters in every treatment therefore it was considered that by placing the lysimeters in Treatments 1 and 5 the likely maximum and minimum nitrogen losses could be measured. Lysimeters were buried to a depth of 30 cm to the top of the lysimeter, placing the vacuum points at 50 cmbelow the surface of the soil. The site was left for 6 months to allow pasture cover to develop over the lysimeters and for the soil to settle to resemble its undisturbed state. A low vacuum of –12 to –10 kPa was applied to the lysimeters. Any leachate that reached 50 cm was collected by the lysimeters and sampled for analysis. Total leachate volume was calculated and converted to millimeters/ha from the diameter of the lysimeter and the volume collected in each 24 hours. After analysis of the leachate samples for nitrate – nitrogen concentration and Kleldahl nitrogen, losses of nitrogen (kg/ha) were calculated.

Pasture harvest

Sampling plots were fenced to prevent grazing. At each dry matter harvest, two quadrants, 2.4m by 1.05m, were cut to 5cm high in each plot. Each fresh sample was weighed and two sub-samples collected (approximately 250 g wet weight) for chemical analysis. Moisture content was determined for each sub sample (80 ^{0}C for 24 hrs). Samples for chemical analysis were dried at 60^{o}C for 48 hours and then ground to 2 mm. After each harvest the remainder of the fenced off plot area was mowed to 5cm and the cut material removed.

Soil analysis

Prior to experimentation (November 2000) each plot was soil sampled to a depth of 20 cm at 10 cm intervals. At the completion of the experiment in March 2001, soil samples to a depth of 80 cm were collected from two sites in each treatment plot in 10 cm segments. Sub-samples were taken from each sample and frozen. The remaining samples were dried at 40^{o}C for 48 hours and stored for later analysis at the University of Queensland, Gatton Campus, School of Agronomy and Horticulture analytical laboratory. The samples were analysed for total Kjeldahl nitrogen (TKN), total Kjeldahl phosphorous (TKP), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), chloride (Cl), organic carbon (OC), pH and electrical conductivity (EC). Frozen samples were analysed for nitrate nitrogen (NO_3-N) and ammonium nitrogen (NH_4).

Results

There was no significant difference in pasture yield between treatments for either total yield or at any of the five harvest times (Table 2). Pasture yields tended to decrease with each harvest although yields were variable.

Table 2: Pasture dry matter at each harvest (kg DM ha^{-1})

Treatment	28 Nov 2000	20 Dec 2000	08 Jan 2001	30 Jan 2001	21 Feb 2001	Total
1	954	1736	922	859	773	5243

2	1497	1423	813	1053	1023	5808
3	1508	1429	888	1256	1132	6213
4	1629	1599	928	1145	734	6035
5	1320	1589	744	1291	892	5836

There was a significant decline in the nitrogen concentration in the pastures across all treatments as the season progressed. The mean nitrogen yield of the pasture was significantly higher in harvests 1 and 2 (28 November, 20 December 2000) than in harvests 3, 4 and 5 (8 January, 30 January and 28 February 2001) (Table 3).

Total leachate volume collected from November 1 to March 31 was 658 mm for Treatment 5 and 542 mm for Treatment 1. This is the equivalent of 51 % and 42 % of rainfall plus irrigation applied. Although analysis of leachate samples for nitrogen is continuing, preliminary results suggest that nearly three times as much nitrogen penetrated to 0.5 m in the high effluent treatment than in the no effluent treatment (Table 4).

Table 3: The plant nitrogen yield at each harvest for each treatment

Treatment	Mean N yield (kg/ha)					
	28 Nov 2000	20 Dec 2000	08 Jan2001	30 Jan 2001	21 Feb 2001	Total
1	31.6	54.7	28.1	24.6	22.8	161.8
2	47.2	45.3	26.3	30.4	29.0	178.2
3	48.6	49.8	26.5	36.0	33.3	194.2
4	56.9	52.5	30.6	36.6	20.9	197.5
5	45.5	58.2	25.8	41.1	26.2	196.9
Mean	46.0[a]	52.1[a]	27.5[b]	33.8[b]	26.4[b]	185.7

lsd ($p<0.05$) = 10.61

Table 4: Monthly nitrate nitrogen and Kjeldahl nitrogen collected in the lysimeters (kg/ha)

Month	Treatment 1	Treatment 5

November	16.39	6.11
December	11.27	16.74
January	1.19	29.68
February	0.23	33.01
March	0.00	1.28
Total	29.09	86.80

There was no significant difference in soil N to a depth of 80 cm at the completion of the experimental period. The nitrogen balance shown in Table 5 indicates that approximately 200 kg ha^{-1} of nitrogen in excess of measured inputs was accounted for in both treatments 1 and 5.

Table 5: The nitrogen balance of treatments 1 and 5 (all values expressed as kg ha^{-1})

	Treatment 1	Treatment 5
Total N applied	0	82.9
Total N removed as plant nitrogen	161.8	196.9
Total N lost as leachate	29.1	86.8

Discussion

These results show that leaching losses of nitrogen increase when effluent is applied in summer (Table 5). Substantial amounts of leachate were collected, representing up to half of the rainfall and irrigation received. Preferential macropore flow may have resulted in greater volumes than expected. Although leachate analysis is continuing, indications so far suggest that an amount equivalent to 68 % of nitrogen applied as dairy effluent was lost through leaching in the high effluent treatment. Decreasing pasture yield and quality with each harvest indicate a decreasing availability of nitrogen possibly due to losses through leaching although soil analysis to 50 cm indicates no substantial change in soil nitrogen. Significantly, some 200 kg N ha^{-1} in excess of the amount of N that was applied was removed in harvested plant material and lost by leaching in both the control and the area receiving effluent. The explanation for this observation is uncertain, and may range from measurement errors to N fixation by soil borne free living bacteria. The discrepancy in N balance needs intense investigation, and may point to a significant soil ecological process.

Conclusion

The research suggests that N leaching to 50 cm may increase when N rich effluents are applied, with the practical implication that such effluents should only be used on areas of low N status and to pastures with high N demand. The study poses several questions, and further research is required using different pasture, soil and management combinations to more fully explore the N balance, movement of N and its transformation in soil following effluent application.

References

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