Nitrogen Balances in High Rainfall, Temperate Dairy Pastures of South Eastern Australia

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NITROGEN BALANCES IN HIGH RAINFALL, TEMPERATE DAIRY PASTURES OF SOUTH EASTERN AUSTRALIA

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Abstract

Nitrogen (N) fertilizer use on dairy pastures in south eastern Australia has increased exponentially over the past 15 years, causing increasing environmental concerns. Volatilisation, denitrification and leaching of N were measured for one year (1998-1999) in pastures receiving no N fertilizer (grass/clover), or 200 kg N/ha applied as urea (46%N) or ammonium nitrate (34.5%N). Nitrogen balances were calculated for each treatment.

Significantly more N was lost through volatilisation and denitrification when N was applied as urea compared to ammonium nitrate. Nitrate leaching losses were significantly greater with the application of N fertilizer, although the maximum loss was only 4.1 kg N/ha due to low rainfall between May and September. Nitrogen balances were -15, +87 and +82 kg N/ha per year for the grass/clover, 200 kg N/ha urea and 200 kg N/ha ammonium nitrate treatments, respectively. Given the large range in N losses and balances, there is opportunity for improving the N efficiency in dairy pastures, through lower stocking rates and more tactical use of grain and N fertilizer.

Keywords: Nitrate leaching, volatilisation, denitrification, urea, ammonium nitrate, clover.

Introduction

Nitrogen (N) fertilizer use on dairy pastures in south eastern Australia has increased exponentially over the past 15 years, leading to increased concerns about environmental impacts of high N use (Eckard *et al.* 1997). The increasing demand for higher production has highlighted the inadequacy of clover-derived N_2 to maximise pasture production, particularly through the cooler months of the year (Eckard and Franks 1998). This paper presents data on N balances for grazed dairy pasture in the temperate high-rainfall region of south eastern Australia.

Material and Methods

An experiment was conducted on the Ellinbank research farm in west Gippsland, Victoria (38° 15' S; 145° 93' E, mean annual rainfall 1114 mm) using a randomised block design with 3 replicates. Treatments were: no N fertilizer (grass/clover), and 200 kg N/ha/year as either urea (46%N) or ammonium nitrate (34.5%N), applied in February, May, July and October. Stocking rate was 1.9 and 2.8 Friesian cows/ha for the 0 and 200 kg N/ha treatments, respectively; the lower stocking rate being consistent with historical management of the paddock. Each cow was fed 550 kg barley over lactation.

Volatilisation and denitrification losses were measured by micrometeorological mass balance with passive samplers (Schjoerring *et al.* 1992) and acetylene inhibition (Ryden *et al.* 1987), respectively. Nitrate leaching was measured from gravel mole drains installed under each treatment separately (Heng *et al.* 1991). Drainage was estimated by water balance (Cameron & Scotter 1987). Monthly evapotranspiration (ET) was calculated using a modified Pennman-Monteith equation (Smith 1992). Rainfall and temperature were measured at the site (Figure 1). Ammonia and nitrate in solution were analysed by flow injection and nitrous oxide by gas chromatography (Ryden *et al* 1987). Clover N_2 fixation was estimated from clover content

(Ledgard *et al.* 1997). N in dung and urine samples was analysed by Kjeldahl, and milk N was determined by Milkoscan (Foss Electric, Denmark).

An annual nitrogen balance was calculated for each of the 9 plots separately for the period May 1998 - May 1999. Data were subjected to analysis of variance.

Results and Discussion

Volatilisation, denitrification and leaching losses were all significantly ($P < 0.05$) greater with the application of N fertilizer (Table 1). Urea lost significantly ($P < 0.05$) more N through volatilisation and denitrification than did ammonium nitrate. Denitrification estimates agree with the data of Ledgard *et al.* (1999), while volatilisation was lower due to cool weather and rainfall events that coincided with measurements. Nitrate leaching losses were significantly ($P < 0.05$) greater with the application of N fertilizer, although N sources were not significantly ($P > 0.05$) different. Nitrate leaching losses were substantially lower than model predictions (Scholefield *et al.* 1991) and New Zealand studies (Ledgard *et al.* 1999), due to rainfall between May and September (Figure 1) being 181 mm lower than the long-term average rainfall.

The nitrogen balances differed significantly ($P < 0.05$) between the grass/clover and 200 kg N/ha treatments. However, the grass/clover system appeared largely in balance, suggesting an unperturbed system, while N fertilised treatments appeared to be immobilising surplus N. The N balances reported here are higher than reported for New Zealand pasture systems (Ledgard *et al.* 1997; Ledgard *et al.* 1999), but similar to Netherlands data where higher grain inputs were linked to increased N conversion efficiency (Neeteson and Hassink 1997). The treatments receiving 200 kg N/ha were significantly ($P < 0.05$) less N efficient (product N/N inputs) than the grass/clover treatment, but were within the 42 - 80% and 25 – 37% range reported for New Zealand pastures receiving 0 and 200 kg N/ha per year, respectively (Ledgard *et al.* 1999).

The grass/clover system, although more lightly stocked and producing less milk per hectare, was 21 – 22% more N efficient, losing significantly less N to the environment, relative to the N fertilised treatments. Given the large range in N losses and balances reported in this study and elsewhere, there is clearly opportunity for improving the N efficiency of dairy production systems. This could be done through more strategic use of grain supplements, but also through lower stocking rates on a grass/clover system, and more tactical use of N fertilizer when plant uptake is high and losses potentially lower.

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Table 1 - Nitrogen inputs and outputs (kg N/ha per year) between May 1998 and April 1999 for grazed dairy pastures varying in N fertilizer rate and source. Means with a common letter do not differ significantly (P>0.05).

	Grass/clover	Ammonium Nitrate	Urea	s.e.d	l.s.d.
N Inputs					
N Fertilizer[1]	0	200	200		
N2 Fixation[2]	108[a]	64[b]	70[b]	13.5	37.4
Rainfall[1]	3.2	3.2	3.2		
Grain[1]	25[a]	36[b]	36[b]	1.4	3.8
Total N Inputs	136[a]	303[b]	309[b]	13.9	38.5
N output in products					
Milk[1]	73[a]	107[b]	112[b]	8.0	22.1
Meat[2]	6[a]	8[b]	9[c]	0.3	0.9
Total	79[a]	115[b]	121[b]	8.2	22.9
N 'Surplus'	57[a]	187[b]	188[b]	12.6	35.0
Product N/N inputs	61 %[a]	38 %[b]	39 %[b]	7.4	20.5
N Losses/removals					
Volatilisation[1]	10.2[a]	16.5[b]	23.6[c]	1.87	5.20
Denitrification[1]	8.0[a]	11.8[b]	13.9[c]	0.39	1.07
Leaching[1]	2.2[a]	4.1[b]	3.5[b]	0.36	1.00
Transfer to lanes/sheds[2]	52[a]	67[a]	66[a]	11.3	31.2
Total losses	73[a]	100[ab]	107[b]	11.0	30.6
Total N Outputs	151[a]	215[b]	228[b]	17.8	49.3
Nitrogen Balance	-15[a]	87[b]	82[b]	18.5	51.3

[1.] Directly measured
[2] Calculated based on key measurements

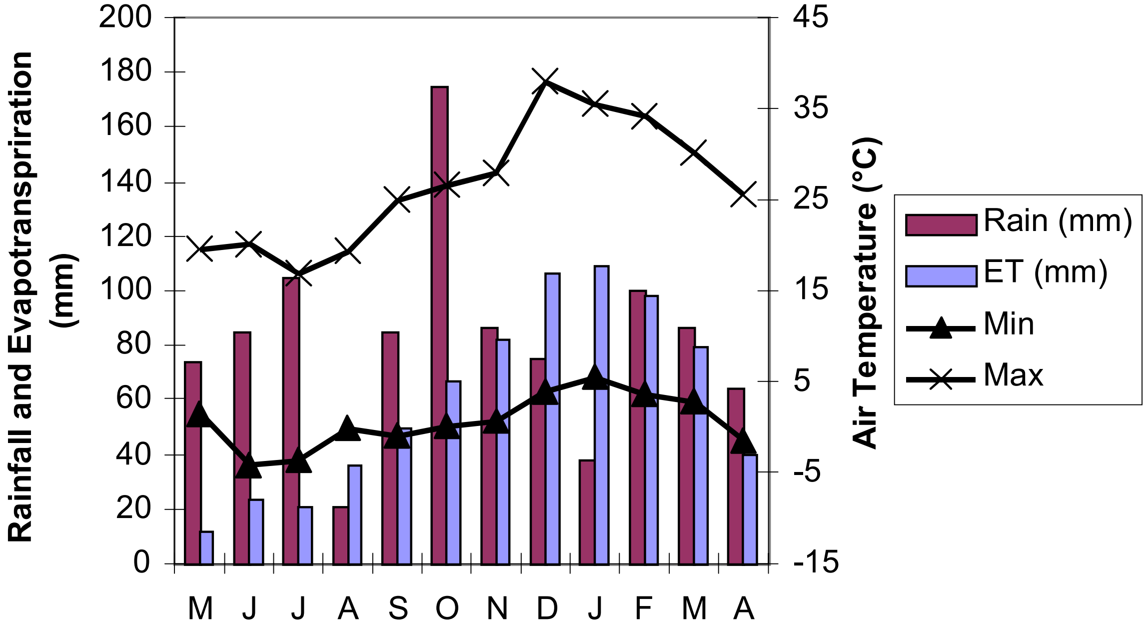

Figure Captions

Figure 1 - Mean monthly rainfall, evapotranspiration and minimum and maximum air temperatures recorded at the site.