PASTURE DRY MATTER YIELD RESPONSE FOLLOWING AN AUTUMN AND SPRING APPLICATION OF ECO-N™AT THE SOUTHLAND DEMONSTRATION FARM.

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Abstract
Nitrogen (N) losses from urine patches in New Zealand grazed pastures are a major source of N loss from our pastoral systems via nitrate (NO_3-) leaching and nitrous oxide emissions (N_2O). The nitrification inhibitor, eco-n (fine particle DCD suspension) has been shown to mitigate such N losses. Six half paddocks on the Southland Demonstration Farm near Wallacetown, New Zealand were treated with the nitrification inhibitor eco-n according to the manufacturer's specifications i.e., eco-n was applied at 10 kg/ha in autumn and spring to half of each of six separate paddocks. These permanent non effluent paddocks were measured each grazing using a rising plate meter to quantify pasture dry matter yield responses to eco-n following a strict measurement protocol. The half paddocks were grazed evenly and urea applied at 170 kg N/ha across both the treated and untreated halves. This paper will present the dry matter results measured over the 2011-12 dairy season at the Southland Demonstration farm.

Keywords: eco-n, dicyandiamide, inhibitors, N_2O, NO_3^-, pasture, urine

Introduction
Nitrogen (N) is an essential element for plant growth, and is often the Key limiting nutrient in grazed pasture systems (Ball et al., 1982; Steele, 1982; Hayes & Williams, 1993). Leaching of soil nitrate (NO¯3) over the winter drainage period represents a significant loss of soil mineral N under the New Zealand grazed pastoral system. Reducing these winter losses will not only reduce the N losses from the farm but will also lead to greater soil N retention, and increased N availability for plant production. The urine patch of the grazing animal has been identified as the main source of N leaching loss in the grazed pasture system (Ryden et al.,m 1984; Ledgard et al., 1999; Silva et al., 1999; Di & Cameron, 2002b)

The use of eco-n™ as a nitrification inhibitor in pasture on New Zealand (NZ) dairy farms has become increasingly common. Published research in 2002 first showed the potential of eco-n™ to reduce the nitrate leaching and nitrous oxide emissions within urine patches (Di & Cameron 2002, Di & Cameron 2005) it was also that the reduction in N losses over the winter months resulted in a potential pasture dry-matter (DM) increases in the eco-m™ treated areas (Moir et al,. 2007; Carey, et al,. 2012).

eco-n™ was first commercialised in 2004 by Ravensdown. A fine particle dicyandiamide (DCD) is applied via a contractor based spray application. There has been increased use of eco-n™ on NZ dairy farms since its introduction to both reduce nitrate losses and boost pasture production. Efficiency to increase pasture production has varied based on geographical regions and other limiting factors to pasture production. A summary of a national trial series of DM responses to the eco-n™ application found that North island responses averaged 14% with a variation of 4-7% in the Waikato to 23-27% in the Taranaki area, South Island average response was 21% with a variation of 6-31% with paddocks at the lower end of the spectrum been the minority (Carey, Jiang and Roberts 2012). Further pasture response work was measures as part of the 'The Pastoral Greenhouse Research Consortium Ltd' (PGgRc) NOMAR trial series, although the primary research was investigation into reductions in Nitrous Oxide losses in grazed pastures through the use of DCD as a nitrification inhibitor, at the same time both Nitrate leaching reductions and pasture DM response was measured. The results across the trial sites are consistent with other trials for nitrous oxide and nitrate leaching reductions, but not for pasture yield responses (Gillingham, et al. 2012). Not all trial areas received the same rates and frequency of DCD applications. It should be noted that this work was at the plot scale which potential does not take into account the variability of the farm system given the random grazing and urination at the paddock and farm scale.

Half paddock trials with eco-n™ have been measured on the Southland Demonstration Farm since 2008/09 season, the previous datasets have all contributed a past paper discussing pasture DM response to eco-n™ (Carey et al,. 2012).

Methods

Farm pasture policy

Pastures are progressively being renewed each year through a renewal programme that incorporates both winter crops such as swedes, kale and fodder beet and short term ryegrasses prior to new permanent pasture being sown. Half of the winter-crop area is returned to new pasture each year and the other half cropped for a second season. The farm has re-grassed approximately 1/3 of the property in the past 4 seasons. Each new pasture is a perennial ryegrass/white clover combination, with strategic placement of particular cultivars across the farm differing in ploidy (diploid/tetraploid), flowering date and more recently different novel endophytes. A small area of the farm was sown directly in short term ryegrass without clover to increase the amount of re-grassing on the farm and address some of the weed issues on farm. The ryegrass acts as a forage crop in its own right, this will be wintered cropped and returned to permanent ryegrass / white clover. Permanent pastures are sown at 20kg/ha diploid ryegrass and 25kg/ha tetraploid ryegrass with 6kg/ha white clover.

Date	pH	OlsenP	K	Sulphate Sulphur	Mg	Ca	Na
2007/08 Average	**6.1**	**29.8**	7.4	**7.5**	**10.7**	**23.2**	**12.7**
2008/09 Effluent	6.3	28.5	9.0	5.5	31.0	14.5	18.5
2008/09 Non Effluent	6.0	34.1	6.9	9.9	22.0	11.3	13.7
2009/10 Effluent	6.0	35.5	10.0	8.5	36.0	14.5	16.5
2009/10 Non Effluent	5.9	34.6	5.8	9.6	22.1	11.1	9.9
2010/11 Effluent	5.9	35.0	7.0	8.3	27.8	12.	14.
2010/11 Non Effluent	5.9	34.4	5.7	8.9	20.2	39.0	58.3
2011/12 Effluent	6.3	33	8	10	34	14	20
2011/12 Non Effluent	6	31.8	7.9	8.8	23	10.8	11.7

Figure 1 Farm soil testing history

Paddock selection

The trials were conducted between April 2011 and May 2012. Paddock selection was based on the following criteria:

1. likely to be grazed in the autumn during April/May
2. uniform in soil type, contour, pasture species, grazing management, fertility and water distribution

Trial and measurement procedure

Paddocks were set up as half-paddock trials, with one half chosen randomly to receive the nitrification inhibitor at the standard rate of eco-n™ (10 kg DCD/ha) while the other half received no eco-n™. eco-n™ was applied twice, April 2011 and July 2011. At 8°C the half-life of eco-n™ in the soil is 111-116 days (Di & Cameron, 2004), these were about 5 times those at 20°C. eco-n™ best practice recommends applications commence at a 16°C and declining soil temperature to maximise soil life.

Grazing occurred on both sides of the paddocks simultaneously. No attempt was made to impose uniform management between paddocks.

At least 60 rising pasture plate measurements were taken by a technician on each half-paddock area, pre and post-grazing, but followed the same path each time, avoiding water troughs, gateways and other non-uniform areas.

Pasture mass data were recorded from the time of DCD application but DM responses largely occurred from July/August onwards. A total of six half paddocks were used for monthly calculations.

Each trial paddock received 125kg/ha of Ammo 31™ providing 38kgN/ha and 18kgS/ha spread evenly in August. In addition to this; a further approximate 212kgN/ha was applied to the farm in the form of urea as feed requirements demanded through the milking season.

The total kg DM/ha for the 2011/12 dairy season was statistically analysed using a paired samples *t* test, with the two half-paddocks within each paddock forming one such pair (with one half-paddock treated with eco-n, and one untreated). For this analysis, the six trial paddocks were regarded as a random sample of the study population, which was the set of all paddocks on the Southland Demonstration Farm (SDF). Statistical results then apply to SDF as a whole

Results

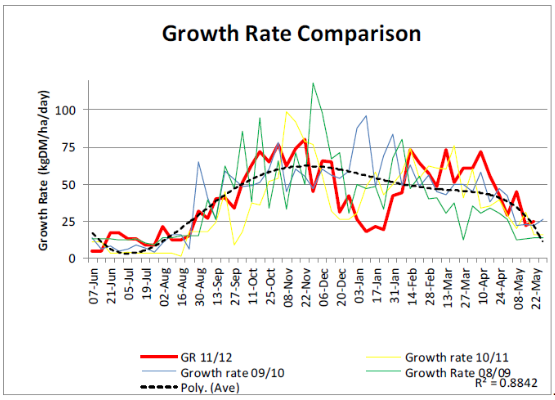

Figure 2 Annual growth rates

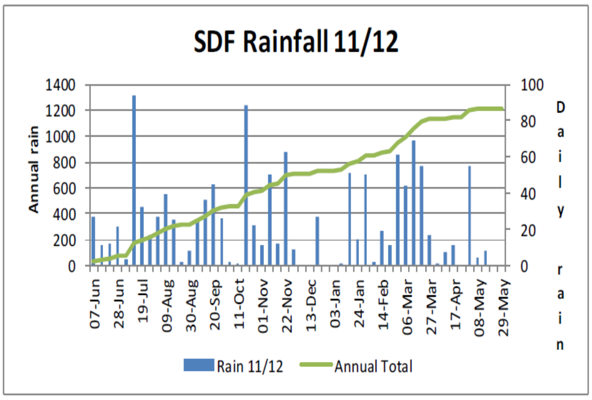

Figure 3 Rainfall over 2011/12 season

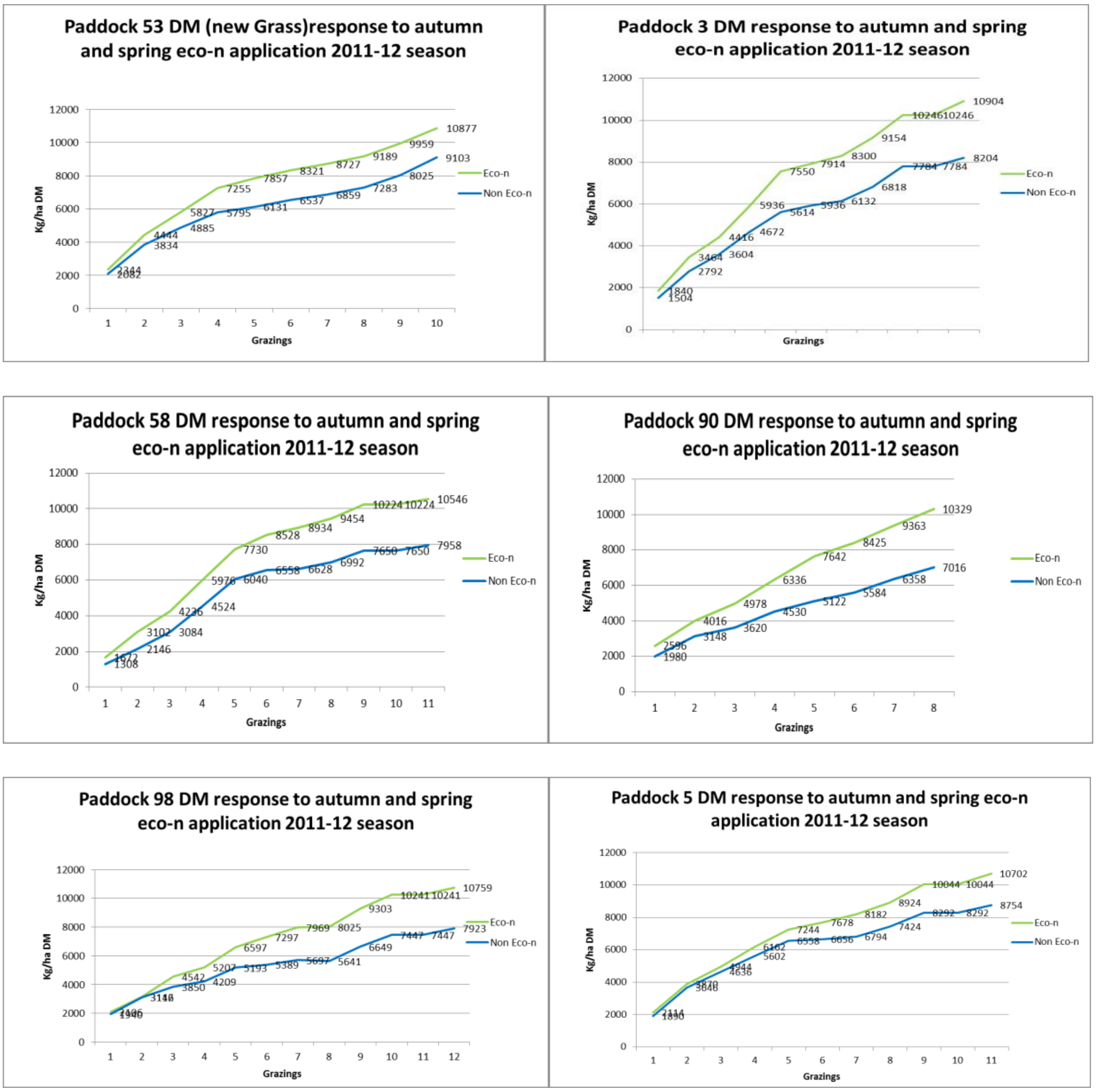

Figure 4 Cumulative Growth Rates by Trial Paddocks

In terms of total DM kg/ha for the 2011/12 dairy season, the mean response to eco-n was estimated to be 2527 kg DM/ha (95% confidence limits: 1924 – 3129). If expressed as a *percentage* increase for each paddock, then the mean percentage increase due to eco-n was estimated to be 32% (95% confidence limits: 21% - 42%). With both variables, the mean response was significantly different from zero at the 0.1% level of statistical significance.

Paddock	No eco-n	eco-n	Difference	% Difference
3	8204	10904	2700	33%
53 (new grass)	9103	10877	1774	19%
58	7958	10546	2588	33%
90	7016	10329	3313	47%
98	7923	10759	2836	36%
5	8754	10702	1948	22%
Mean	**8160**	**10686**	**2527**	**32%**
95% confidence interval			**(1924 - 3129)**	**(21% - 42%)**

Table 1 Paddock Results

Mean	31.7%	2527
SD	10.0%	574
SE(mean)	4.1%	234
Critical t-value	2.571	2.571
95%CI half-width	10.5%	603
Lower Conf. Limit	21.2%	1924
Upper Conf. Limit	42.2%	3129
t=Mean/SE(mean)	7.779	10.776
Significance of difference	0.1% sig	0.1% sig

Table 2 Upper and Lower Confidence Limits.

Discussion

When no eco-n™ was applied half-life of Ammonium (NH+4) was 44 days. However when eco-n™ was applied at 7.5kg/ha and 15kg/ha, the half-life was increased to 243 and 491 days, respectively (Di & Cameron 2004). The NH+4 concentrations decrease more rapidly at 20°C in non-treated eco-n™ plots NH+4 half-life was 22 days, this was increased to 64 and 55 days when eco-n was applied at 7.5 and 15 kg/ha, respectively.

This farm trial suggests there is strong evidence that the use of eco-n positively effects dry matter production. This increase in DM production is likely to occur through a reduction in N loss resulting from the application of eco-n. Why these farm trial results exceed response values from experimentally based plot trials? Some of the differences can be accounted for in the application rates of the DCD, frequency of application and timing of application. However the random urine events from the grazing animal are very difficult to capture and account for at the plot scale.

There remains a significant amount of research on-going to understand how DCD based nitrification inhibitors perform under varying climates and soil types, and how performance can be optimised. However, these questions must be answered on a farm scale basis rather than small scale pasture production trials.

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