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**THE ROLE OF INHIBITORS IN MITIGATING
NITROGEN LOSSES FROM CATTLE URINE
AND NITROGEN FERTILISER INPUTS IN
PASTURES**

**A thesis presented in partial fulfilment of the
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Abstract

The major land use in New Zealand is pastoral farming of sheep and cattle. In intensively grazed dairy-pasture systems, animals graze on nitrogen (N)-rich legume-based pastures, but do not efficiently utilize the N they ingest. On average only 10.5% of the N in forage-based animal feed is converted into milk and the remainder is excreted in dung and urine. In the pastures, a cow urine patch can typically contain up to 1000 kg N ha⁻¹. Nitrogen input, either in the form of cow urine or fertilizer, often exceeds immediate plant requirements and hence is susceptible to losses as ammonia (NH₃) volatilisation and nitrous oxide (N₂O) emissions and removal in drainage water through nitrate (NO₃⁻) leaching. This loss of N from grazed pastures causes detrimental environmental impacts in the form of acidification and eutrophication of the soil and water bodies, global warming, destruction of stratospheric ozone, and NO₃⁻ toxicity.

Various approaches have been attempted to mitigate the economic and environmental impacts of N losses. One such approach is the use of Urease (UIs) and Nitrification (NIs) inhibitors. There have been extensive studies on the value of UIs in arable farming and NIs in grazed pastures. However, only limited work on the impact of UI and NI alone and in combination in influencing the N dynamics, and thus mitigating N gaseous losses from pastures, has been conducted.

This thesis examines the impact of UI (Agrotain; N-(n-butyl) thiophosphoric triamide) and NI (Dicyandiamide, commonly known as DCD), when applied alone or in combination to cow urine and urea fertiliser, on N losses through NH₃ and N₂O emissions and NO₃⁻ leaching, and on herbage production under glasshouse conditions and a field-plot study. The degradation rate of DCD, and its effect on nitrification and on N₂O emissions from four soils varying in their physical and chemical properties was also examined under laboratory incubations. The results from the field-plot study were then used to predict the effect of DCD on N₂O emissions reductions from urine by adapting the process-based NZ-DNDC model.

Both NH₃ and N₂O emissions have common sources in agriculture. Therefore, chambers were adapted to measure their emissions simultaneously using active and passive gas sampling. Active sampling involved continuous air flow and the use of acid

(0.05 M H₂SO₄ and 2% H₃BO₃) traps for NH₃ measurements and passive sampling involved collecting three gas samples over a one-hour period from a static chamber used for N₂O emissions.

The first glasshouse experiment used UI with urine or urea to assess its effect on NH₃ and N₂O emissions, changes in soil mineral-N and N uptake by pasture plants. The UI treatments also involved two commercial products, Sustain Yellow (urea coated with Agrotain and elemental S) and Sustain Green (urea coated with Agrotain). The use of UI effectively decreased total NH₃ emissions, as well as delaying the time of maximum NH₃ emissions from both urea (600 kg N ha⁻¹) and urine (476 kg N ha⁻¹) by 27% and 22%, respectively. The UI-induced decrease in NH₃ volatilization ranged from 42-48% when urea was applied @ 100 kg N ha⁻¹. Urease inhibitor was also effective in decreasing N₂O emissions significantly from urine and urea applied @ 100 kg N ha⁻¹. The addition of UI increased dry matter yield by 13-19% as compared to the urea-alone treatment.

In the second glasshouse study, NI (DCD) was added @ 25 kg ha⁻¹ to urea (@ 25, 50 and 75 kg N ha⁻¹) and urine (@ 144, 290 and 570 kg N ha⁻¹) applied at different rates. Addition of DCD reduced N₂O emissions from both urea and urine and NO₃⁻ leaching from urine. Dicyandiamide reduced N₂O emissions by 34-93% from the added urea and 33-80% from the added urine. However, its use increased the amount of ammonium (NH₄⁺) present in the soil by 3 to 13% both in the urea and urine treatments, and this NH₄⁺ was susceptible to leaching and volatilisation losses. The addition of DCD, however, resulted in a 60-65% reduction in NO₃⁻ leaching from urine applied to pasture soil cores. It also caused a significant reduction in NO₃⁻-induced cation leaching. Leaching of K⁺, Mg⁺² and Ca⁺² ions was reduced by 36-42%, 33-50% and 72%, respectively, with DCD applied to cattle urine (290 and 570 kg N ha⁻¹).

The combined use of UI and NI was more effective in controlling N gaseous losses than using them individually. The combination of UI and NI retarded NH₃ emissions by 70% in the urea treatment and by 4% in the urine treatment (field-plot study). It also considerably reduced N₂O emissions (50-51%) following the application of urea and urine (field-plot study) to pasture soil. With the combined inhibitors, there was a 14 and 38% increase in herbage yield from added urea and urine (field-plot study), respectively.

A laboratory incubation experiment was undertaken to study the effect of soil types and the rate of DCD application on the degradation kinetics of DCD. The rate of degradation of DCD varied among the four soils studied. The degradation was slowest (half-life period of 6 to 11 days) in an allophanic soil with a high concentration of organic matter. The effectiveness of DCD in inhibiting nitrification also varied depending on the nature and amount of soil organic matter and clay content. The maximum inhibition was observed in a soil with low organic matter and high clay content.

Finally, 'NZ-DNDC', a process-based model, was adapted and used to simulate the effect of DCD on emissions reduction using DCD inhibition values that vary according to different soil types. This model effectively simulated the effect of DCD on N₂O emissions reductions in Tokomaru silt loam following urine application. However, more field data are required from a range of pasture soils with contrasting amount of soil organic matter and clay content under differing climatic conditions to further test this model modification to predict emission-reductions with DCD application in different soil types

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Table of Contents

Abstract.....	i
Acknowledgements	iv
Table of Contents	vi
List of Tables	xi
List of Figures	xiv
List of Plates.....	xx
Chapter 1 Introduction.....	1
1.1 The issue	1
1.2 Research Objectives	3
1.3 Thesis Structure.....	4
Chapter 2 Review of Literature.....	9
2.1 Introduction.....	9
2.2 Issues.....	9
2.3 Sources of nitrogen input in grazed pastures	11
2.4 Nitrogen dynamics in pasture soils.....	15
2.4.1 Mineralisation.....	16
2.4.2 Nitrification	16
2.4.3 Immobilisation.....	17
2.4.4 Denitrification	17
2.4.5 Ammonium fixation.....	18
2.4.6 Nitrate leaching	18
2.4.7 Ammonia volatilisation.....	18
2.5 Environmental impact of N losses.....	19
2.6 Inhibitors in nitrogen cycle	21
2.6.1 Urease Inhibitors	22
2.6.2 Nitrification Inhibitors	25
2.7 Changes in availability of N with inhibitors	28
2.8 Effect of inhibitors on N losses	34
2.9 Conclusions.....	37

Chapter 3	Development of methodology for simultaneous measurement of ammonia and nitrous oxide emission from soil cores.....	39
3.1	Introduction.....	39
3.2	Materials and Methods	40
3.2.1	Standards and reagents	40
3.2.2	Description of sampling system / instrumentation	41
3.2.3	Efficiency of ammonia absorption	42
3.2.4	Evaluation of the developed chamber equipment for simultaneous measurement of ammonia and nitrous oxide	44
3.2.5	Comparison of active vs passive samplers for ammonia volatilisation.....	46
3.2.6	Statistical methods.....	49
3.3	Results	50
3.3.1	Recovery of ammonia.....	50
3.3.2	Technique evaluation.....	51
3.3.3	Comparison of Active vs Passive samplers	54
3.4	General Discussion.....	56
3.5	Summary and Conclusions	59
Chapter 4	Effect of urease inhibitor (Agrotain) on gaseous emissions of nitrogen from cattle urine and urea fertiliser	61
4.1	Introduction.....	61
4.2	Materials and Methods	63
4.2.1	Experimental details	63
4.2.2	Gaseous measurements.....	65
4.2.3	N recovery.....	66
4.2.4	Analysis	67
4.2.5	Statistical Methods	68
4.3	Results	68
4.3.1	Experiment 1	68

4.3.2	Experiment 2	76
4.4	General discussion.....	83
4.5	Conclusions.....	88

Chapter 5 Influence of nitrification inhibitor (DCD) on the gaseous and leaching losses of nitrogen from urea and cattle urine in pasture soil..... 89

5.1	Introduction.....	89
5.2	Materials and Methods	91
5.2.1	Experimental details	91
5.2.2	Gaseous emissions.....	93
5.2.3	N recovery.....	94
5.2.3	Analysis.....	94
5.2.4	Statistical Methods	95
5.3	Results.....	96
5.3.1	Experiment 1	96
5.3.2	Experiment 2	104
5.4	General Discussion.....	119
5.5	Conclusions.....	125

Chapter 6 Combined effect of urease and nitrification inhibitors on N dynamics in pasture soils..... 127

6.1	Introduction.....	127
6.2	Materials and Methods	128
6.2.1	Experimental set-up	128
6.2.2	Ammonia measurements.....	131
6.2.3	Nitrous oxide measurements.....	131
6.2.4	Soil Sampling and analysis	132
6.2.5	Herbage analysis.....	133
6.2.6	DCD Degradation.....	133
6.2.7	Statistical Analysis	134
6.3	Results.....	134
6.3.1	Ammonia emissions.....	134

6.3.2	Nitrous oxide emissions.....	136
6.3.3	DCD degradation analysis	138
6.3.4	Nitrogen transformation.....	140
6.3.5	Dry matter yield and nitrogen uptake.....	146
6.3.6	Water-filled pore space.....	148
6.4	General discussion.....	149
6.5	Conclusions.....	154

**Chapter 7 Degradation kinetics of dicyandiamide in four soils
and its effect on nitrous oxide emission – an
incubation study..... 155**

7.1	Introduction.....	155
7.2	Materials and Methods	157
7.2.1	Soil sampling and preparation.....	157
7.2.2	Experimental set-up.....	157
7.2.3	Soil analysis	159
7.2.4	Estimation of nitrification inhibition index.....	160
7.2.5	Dicyandiamide half-life	160
7.2.6	Statistical analysis	160
7.3	Results	161
7.3.1	Degradation of DCD.....	161
7.3.2	Effect of DCD	163
7.4	General Discussion.....	178
7.5	Conclusions.....	181

**Chapter 8 Modelling the effect of nitrification inhibitor (DCD)
on nitrous oxide emissions from urine application 183**

8.1	Introduction.....	183
8.1.1	Model Description.....	185
8.1.2	Input parameters	188
8.1.3	Model adaptation.....	188
8.2	Materials and Methods	189
8.3	Results and Discussion	190

8.3.1	Model parameterisation	190
8.3.2	Model Simulated N ₂ O emission, WFPS and mineral N	190
8.3.3	Comparison of the measured and modelled N ₂ O emission, WFPS and mineral N data.....	194
8.4	Conclusions.....	197
Chapter 9 Summary and Conclusions		199
9.1	Nitrogen in grazed pastures.....	199
9.2	Nitrogen loss and effect of inhibitors	200
9.2.1	Ammonification and nitrification reactions	201
9.2.2	Ammonia volatilisation.....	202
9.2.3	Nitrous oxide emissions	203
9.2.4	Nitrogen leaching	204
9.2.5	Nitrogen-induced cation leaching.....	205
9.2.6	Nitrogen-use efficiency.....	205
9.3	Modelling the effect of inhibitors.....	206
9.4	Future research	207
References		211
Appendices		
Appendix 1		239
Appendix 2.....		241

List of Tables

Table 2.1	Effect of N fertiliser in reducing biological N fixation (BNF) in New Zealand pastures	13
Table 2.2	Selected references on the effect of urease inhibitors (UIs) in nitrogen economy.....	32
Table 2.3	Selected references on the effect of nitrification inhibitors (NIs) in nitrogen economy.....	33
Table 3.1	Ammonia recovered under active and passive sampling at high levels of NH ₃ -N addition.....	57
Table 4.1	Chemical and physical properties of the soil from 0-50 and 50-100 mm depths	64
Table 4.2	Characteristics of N treatments used in Experiments 1 and 2	65
Table 4.3	Total N applied and N emitted as NH ₃ and N ₂ O (g N m ⁻²) over the experimental period from various treatments with and without UI.....	71
Table 4.4	Total N applied and N emitted as NH ₃ -N and N ₂ O-N (g N m ⁻²) over the experimental period from urea treatments with and without UI.....	78
Table 5.1	Total N applied (g N m ⁻²) and total N emitted as NH ₃ -N and N ₂ O-N (mg m ⁻² soil) over the experimental period from soil cores receiving varying urea rates with and without DCD.....	99
Table 5.2	Total DM yield, percent of added N in DM and DM response to the N added as urea to the soil cores.....	102

Table 5.3	The amount of N (mg kg^{-1} soil) as NH_4^+ and NO_3^- in the soil, N lost as NH_3 and N_2O and plant N measured following the application of varying rates of urea with and without DCD to intact soil cores.....	104
Table 5.4	Total N applied and N emitted as NH_3 and N_2O (g N kg^{-1} soil) over the experimental period (50 days) from soil cores receiving varying urine rates with and without DCD.....	107
Table 5.5	Total DM yield, percent of added N in DM and DM response to the N added as urine to the soil cores.....	111
Table 5.6	The amount of N (mg kg^{-1} soil) as NH_4^+ and NO_3^- in the soil, N lost as NH_3 and N_2O and plant N measured in intact soil cores receiving varying rates of urine \pm DCD, at the end of the experiment	112
Table 5.7	Total leaching losses of K^+ , Mg^{+2} , Ca^{+2} , NH_4^+ -N and NO_3^- -N in the cumulative drainage of 132 mm from the soil cores receiving urine at varying rates, with and without DCD.....	116
Table 6.1	Treatments applied in the glasshouse study and Field-plot experiment	130
Table 6.2	Chemical and physical properties of Tokomaru silt loam soil at the experimental site.....	130
Table 6.3	Total N applied and N emitted as NH_3 and N_2O (g N m^{-2}) over the experimental period from soil cores receiving urea with and without urease and nitrification inhibitors.....	137
Table 6.4	Total N applied and N emitted as N_2O (kg N ha^{-1}) over the experimental period from plots receiving various treatments	138

Table 6.5	Half-life ($t_{1/2}$) of DCD in plots receiving urine with DCD alone and combined with Agrotain	139
Table 6.6	Nitrification rate in various treatments in the Tokomaru silt loam soil in the field-plot study.....	146
Table 6.7	Total DM yield, percent N in DM and N uptake by the herbage from soil cores receiving urea with and without inhibitors.....	147
Table 6.8	Total dry matter (DM) yield, percent of added N in DM and DM response to the added urine-N in autumn with and without urease and nitrification inhibitors	148
Table 7.1	Selected properties of the soils sampled at 0-10 cm depth.....	157
Table 7.2	Half-life ($t_{1/2}$) of DCD in four soils following the application of urine (600 mg N kg ⁻¹ soil) and DCD at the rates of 10 and 20 mg DCD kg ⁻¹ soil.....	161
Table 7.3	Total N emitted as N ₂ O-N (mg N kg ⁻¹ soil) for the four soils over the incubation period of 50 days	165
Table 7.4	Levels of significant differences between soil type and DCD rates on NH ₄ ⁺ -N, NO ₃ ⁻ -N and DCD-N concentrations in the soil at different times during the experiment.	171
Table 7.5	Total microbial biomass C (mg kg ⁻¹ soil) for various treatments in four different soils at various periods during the incubation.....	175
Table 8.1	Range and means of simulated and measured NH ₄ ⁺ -N and NO ₃ ⁻ -N in the pasture soil for the control, urine and urine+DCD treatments. Mean values are given in brackets.	193

List of Figures

Figure 2.1	The influence of increased nitrogen fertiliser application on biological N fixation (BNF) in legume-based pastures.....	13
Figure 2.2	Schematic representation of nitrogen transformations in legume-based pastures.	15
Figure 2.3	Schematic representation of nitrogen metabolism in plants. (NR denotes <i>nitrate reductase</i>).....	30
Figure 3.1	Schematic diagram of the basic component used in the method developed for simultaneous measurement of NH ₃ and N ₂ O.	42
Figure 3.2	Recovery of NH ₃ with both active and passive sampling using 2% H ₃ BO ₃ (w/v) and 0.05 M H ₂ SO ₄ as absorbents.....	50
Figure 3.3	Ammonia recovered in active and passive sampling techniques from various levels of NH ₃ addition.....	51
Figure 3.4	Ammonia emissions from urine and urea applications	52
Figure 3.5	The percent losses as NH ₃ and N ₂ O-N of applied N as urine and urea.	52
Figure 3.6	Nitrous oxide losses from urine and urea applications.....	53
Figure 3.7	Relationship between NH ₃ emissions measured by active and passive sampling techniques (a) under glasshouse (b) under field conditions (please note different units used for two axis).	55
Figure 4.1	Ammonia emissions from urine and urea applications, with and without UI. The inset gives the enlarged graph for NH ₃ emissions in the urine and urine+UI treatments.....	70

Figure 4.2	Nitrous oxide emissions from urine and urea applications, with and without UI. The inset gives the enlarged graph for N ₂ O emissions in the urea and Sustain Yellow treatments.	71
Figure 4.3	Distribution of (a) NH ₄ ⁺ and (b) NO ₃ ⁻ concentrations in soil cores at 0-50 mm and 50-100 mm depths in various treatments with and without UI.	73
Figure 4.4	Recovery of N fractions (NH ₃ and N ₂ O emitted during the experiment and N present as NH ₄ ⁺ and NO ₃ ⁻ -N in the soil at the end of the experiment) from N applied as urine and urea, with and without added UI.	74
Figure 4.5	pH distribution in Manawatu sandy loam soil receiving added urine and urea, with and without UI.....	75
Figure 4.6	Ammonia emissions from the urea and amended-urea treatments.....	77
Figure 4.7	Nitrous oxide emissions from the urea and amended-urea treatments.....	78
Figure 4.8	Distribution of (a) NH ₄ ⁺ and (b) NO ₃ ⁻ concentrations in soil cores at 0-50 mm and 50-100 mm depths receiving urea and amended-urea treatments.	80
Figure 4.9	pH distributions with and without added urea and amended-urea in Manawatu sandy loam soil.	81
Figure 4.10	Recovery of N fractions (NH ₃ and N ₂ O emitted during the experiment and N present as NH ₄ ⁺ and NO ₃ ⁻ -N in the soil at the end of the experiment) from N applied as urea and amended-urea.....	83
Figure 5.1	Ammonia volatilisation losses from urea, with and without DCD, applied at different rates to Manawatu sandy loam soil.....	97

Figure 5.2	Nitrous oxide losses from urea, with and without DCD, applied at different rates to Manawatu sandy loam soil.	98
Figure 5.3	Distribution of (a) NH_4^+ and (b) NO_3^- concentrations in soil cores at 0-50 mm and 50-100 mm depths receiving urea, with and without DCD, at varying rates.....	101
Figure 5.4	Percent of total N recovered in N fractions in various treatments at the end of the Experiment 1.	103
Figure 5.5	Ammonia volatilisation losses from urine applied with and without DCD at different rates to Manawatu sandy loam..	105
Figure 5.6	Nitrous oxide losses with and without DCD from urine applied at different rates from Manawatu sandy loam soil.....	106
Figure 5.7	Distribution of (a) NH_4^+ and (b) NO_3^- concentration in soil cores at 0-50 mm and 50-100 mm depths receiving urine, with and without DCD, at varying rates..	109
Figure 5.8	The percent of applied N lost as NH_3 and N_2O , plant uptake and mineral N left in the soil cores receiving varying rates of urine±DCD at the end of the experiment.....	112
Figure 5.9	Concentrations of (a), NH_4^+ -N and (b), NO_3^- -N in the drainage water from soil cores receiving urine @ 29 g N m ⁻² and 57 g N m ⁻² with and without DCD.....	114
Figure 5.10	Total leaching losses of N in the leachate from soil cores receiving urine @ 29 g N m ⁻² and 57 g N m ⁻² , with and without DCD.....	115
Figure 5.11	Concentrations of (a) K^+ ; (b) Mg^{+2} and (c) Ca^{+2} in the drainage water from the soil cores receiving urine @ 29 g N m ⁻² and 57 g N m ⁻² , with and without DCD.....	117

Figure 5.12	The relationship between the concentration of NO_3^- and cations (Ca^{+2} , Mg^{+2} , K^+ and NH_4^+) and NO_3^- in the leachate from the soil cores.....	118
Figure 6.1	Daily rainfall and soil temperature (0-50 mm) distribution for May to July 2005 for the field-plot study.....	129
Figure 6.2	Ammonia volatilisation losses from urea applied, with and without urease and nitrification inhibitors.....	135
Figure 6.3	The amount of $\text{NH}_3\text{-N}$ released following the urine application with urease and nitrification inhibitors, relative to urine alone.....	135
Figure 6.4	Nitrous oxide losses from urea applied with and without urease and nitrification inhibitors.....	136
Figure 6.5	Nitrous oxide fluxes ($\text{kg N ha}^{-1}\text{d}^{-1}$) following the application of urine, with and without urease and nitrification inhibitors, in autumn to pasture on Tokomaru silt loam.....	138
Figure 6.6	Mean DCD concentrations in Tokomaru silt loam following the application of urine treatments with DCD alone and combined with Agrotain.....	139
Figure 6.7	Distribution of (a) NH_4^+ and (b) NO_3^- concentration at 0-50 mm and 50-100 mm depths in soil cores receiving urea, with both urease and nitrification inhibitors.....	141
Figure 6.8	Distribution of soil $\text{NH}_4^+\text{-N}$ concentration at (a) 0-50 mm and (b) 50-100 mm depth following the application of urine, with and without urease and nitrification inhibitors, to pasture on Tokomaru silt loam.....	143
Figure 6.9	Distribution of soil $\text{NO}_3^-\text{-N}$ concentration at (a) 0-50 mm and (b) 50-100 mm depth following the autumn application of urine, with and without urease and nitrification inhibitors to the pasture on Tokomaru silt loam.....	145

Figure 6.10	WFPS distribution (0-50 mm) for all the treatments in the field-plot study on Tokomaru silt loam.	149
Figure 6.11	pH distribution (0-50 mm) in Tokomaru silt loam with application of water and urine, with and without N inhibitors..	151
Figure 7.1	Mean DCD concentration in (a) Tokomaru silt loam (b) Manawatu sandy loam (c) Egmont brown loam (d) Horotiu silt loam following the application of urine with DCD applied at 10 and 20 kg ha ⁻¹	162
Figure 7.2	Nitrous oxide losses for various treatments from (a) Tokomaru silt loam (b) Manawatu sandy loam (c) Egmont brown loam (d) Horotiu silt loam during the incubation period.....	164
Figure 7.3	Cumulative amount of CO ₂ released in various treatments during the incubation of (a) Tokomaru silt loam (b) Manawatu sandy loam (c) Egmont brown loam (d) Horotiu silt loam.....	167
Figure 7.4	Mean NH ₄ ⁺ -N concentrations for various treatments in (a) Tokomaru silt loam (b) Manawatu sandy loam (c) Egmont brown loam (d) Horotiu silt loam.....	169
Figure 7.5	Mean NO ₃ ⁻ -N concentrations for various treatments in (a) Tokomaru silt loam (b) Manawatu sandy loam (c) Egmont brown loam and (d) Horotiu silt loam.....	172
Figure 7.6	Mean Nitrification inhibition index (NII) at various periods after urine application with two rates of DCD in the (a) Tokomaru silt loam (b) Manawatu sandy loam (c) Egmont brown loam and (d) Horotiu silt loam..	173
Figure 7.7	Geometric mean of pH levels at different periods following the application of various treatments .in (a) Tokomaru silt loam (b) Manawatu sandy loam (c) Egmont brown loam and (d) Horotiu silt loam	177

Figure 8.1	Structure of the DNDC model (Li <i>et al.</i> 1992a)	186
Figure 8.3	NZ-DNDC modelled N ₂ O emissions for the urine+DCD plots using N _{eff} factor 0 to 1.....	190
Figure 8.4	Measured and NZ-DNDC simulated N ₂ O emissions for (a) the control treatment (b) the urine-only treatment. The measured values are the mean of three replicates.....	191
Figure 8.5	Mean measured and simulated WFPS for all the treatments in the field-plot study. The measured values are the mean of all the five treatments.....	193
Figure 8.6	Measured and simulated N ₂ O emissions for the urine+DCD treatment using Neff values of 0.6 and 0.8. The measured values are the mean of three replicates.....	195
Figure 8.7	Total measured and simulated N ₂ O emission for the control, urine and urine+DCD treatments.....	195

List of Plates

Plate 3.1	Chambers used for simultaneous measurement of NH_3 and N_2O emissions.....	42
Plate 3.2	Three passive samplers placed on three cores in the chamber	47
Plate 3.3	Passive samplers placed in a plot during the field study	49
Plate 4.1	Three intact cores placed in each chamber during the experiment	63
Plate 5.1	Apparatus used for leaching of soil cores.....	93