THE NEW ZEALAND PASTORAL GREENHOUSE GAS RESEARCH STRATEGY

2ND ANNUAL REPORT TO THE CROWN ON PROGRESS

JULY 2005

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PASTORAL GREENHOUSE GAS CONSORTIUM PARTNERS

Participants
Fonterra Co-Operative Ltd
Meat and Wool NZ Ltd
Dairy InSight Inc.
Wrightson Ltd
New Zealand Fertiliser Manufacturers Research Association Inc.
DEEResearch Ltd
AgResearch Ltd
Associate Members
National Institute for Water and Atmosphere (NIWA)
Ministry for Agriculture and Forestry (MAF)
Research Providers and Contributors
AgResearch
Livestock Improvement Corporation (BoviQuest)
Dexcel
Lincoln University
Ravensdown Ltd
Queensland Department of Primary Industries and Fisheries.

PGGRC Chairman: Mark Leslie
Ph 09 374 9000
Mob 021 832941
Mark.leslie@pggrc.co.nz

PGGRC Manager: Mark Aspin
Phone: 04 4716031
Mob 0272483509
Email: mark.aspin@pggrc.co.nz
Web www.pggrc.co.nz

Any correspondence in relation to this report should be addressed to the manager in the first instance.

INTRODUCTION

This second report to the Crown on the investment by the pastoral sector into the mitigation of agricultural greenhouse gases covers the year from July 2004 to June 2005, being the third year of the five year initial consortium period. Since the submission of the first report the Kyoto protocol has been ratified and is now binding. The recent announcement of the expected position for New Zealand at the end of the first commitment period in 2012 identified the significant challenge the sector faces in assisting New Zealand to meets it commitments under this treaty.

The programme of activity that is reported here is driven by the pastoral greenhouse gas research strategy developed and appended to the Memorandum of Understanding (MOU) between the Pastoral Greenhouse Gas Research Consortium (PGGRC) parties and the Crown. The goals of the strategy which aims to develop safe, cost-effective greenhouse gas abatement technologies that will seek to reduce methane and nitrous oxide emissions from livestock by at least 20 percent by 2012 are as follows:

- To identify, establish and develop on-farm technologies to improve production efficiency for ruminants;
- To identify, establish and develop on-farm technologies for sheep, dairy and beef cattle and deer, which lower methane emissions from New Zealand ruminants and nitrous oxide from grazing animal systems; and
- To exploit commercial opportunities arising from the science and technologies in a global market.

Looking to the future, in 2005-2007 the PGGRC's investment will be focused on building on the knowledge gained to rapidly develop the most promising technologies for mitigation. The strategy will be to build on the knowledge and evolve the research programme accordingly. The challenge of integrating that knowledge in to farm systems is not insignificant and will require continued collaboration with many organisations through out the sector and government. The consortium believes that it is well placed after 3 years to meet this challenge and looks forward to building the ongoing relationships needed to ensure that we achieve our mitigation targets.

EXECUTIVE SUMMARY

Research progress has been excellent in all aspects of the research strategy. Our understanding of the microbial dynamics of the rumen continues to expand. This knowledge and the tools developed will be of immense value going forward and the approach of building underpinning knowledge is in line with the Research Strategy.

Although no methane mitigation technology has been proven we have strong leads identified towards that end. A mixture of opportunities have been identified and will be developed further within the research strategy. These opportunities span from specifically targeting the methanogen and rumen microbes to diet manipulation, and through animal selection.

We have a solid set of tools and understanding developing of the rumen that will help us to be more effective in identifying effective mitigation technologies. And consequently develop cost effective mitigation strategies.

Nitrous Oxide mitigation through nitrification inhibitors is well advanced and available to farmers now, as the understanding of these products expands we confidently believe that producers will realise the opportunity they offer to more efficiently manage the nitrogen cycle within farm systems. The more complete understanding of how farm management practices can enhance the management of N_2O emissions will also offer opportunity to farmers to reduce their emissions.

PGGRC is conscious of its expanding role and welcomes more involvement with the crown agencies in developing the understanding of the agricultural greenhouse gas story and effective policies that are advantageous to the sector in mitigating greenhouse gases and driving productivity. In response to this the PGGRC has increased the level of management resourcing supporting this activity.

We continue to look for opportunity to enhance our research strategy and are currently in negotiation to increase our investment further and accelerate the most promising opportunities.

International cooperation in greenhouse gas research is an opportunity for increased leverage that we are evaluating and will develop further if appropriate through direct investment and or research programme collaboration. PGGRC already has effective collaboration occurring with international researcher groups and this has every possibility of further expansion.

Our accumulation of methane and nitrous oxide measurements present a real opportunity to identify more accurately the non-CO2 greenhouse gas output of our farm systems and if appropriate revisit the emission factors allocated. We will work with the Crown on developing this information so that it meets the IPCC standards.

A further PhD scholar has been added to the research programme expanding the expertise that the sector will have in this research area for future mitigation solutions.

PGGRC continue to leverage other trials to drive efficiencies in research delivery. Outside the PGGRC, significant other research is being carried out that has application to the Agriculture greenhouse gas issue both by Crown agencies and also by other industry players. These activities add more context to the situation and the knowledge they generate will be useful for both inventory and mitigation purposes.

PGGRC has become more active in the sector through its personnel delivering a number of presentations, involvement in sector wide forums and the launch of a website late in 2004.

2. THE MAIN ACHIEVEMENTS OF THE PROGRAMME

METHANE

The programme of research into methane mitigation is broad and represents a comprehensive and integrated effort to understand how methane is produced by our ruminant livestock and develop this knowledge for use in its abatement. It covers aspects of methanogen genomics, rumen ecology, forage plant interaction and selection for animal variation.

The research strategy identified that the complexity of the rumen would require a integrated approach across all of these areas to deliver sustainable abatement solutions, along with validation in farm systems before they could be released to industry. As our understanding develops the integration of this knowledge will become a feature of the research strategy.

RUMEN MICROBIAL STRATEGIES TO LOWER METHANE EMISSIONS

This section of the strategy investigates the Microbial population focusing on aspects that affect not only methane production but also importantly its effect on plant digestion. The rumen is a complex ecosystem which consists of large numbers of different microbial species and genera. Our research strategy has been to develop a set of tools for characterizing microbial populations, the relationships between the different populations, identify those inhibiting methanogens, and identify the opportunities for other microbes to act as a alternative hydrogen sinks to replace methanogens.

Progress to date includes :

Methanogens

- A new molecular method for fingerprinting methanogen populations in DNA extracts from rumen samples was established and applied. This will be used to determine factors affecting methanogen survival, and to measure the diversity of methanogens in NZ ruminants.

- A robust and reproducible culture assay to accurately screen anti-methanogen agents and plant tissues was established and developed.

- The first investigation on methanogens establishing in NZ newborn calves has shown that methanogens are present in the developing rumen 1-2 days after birth. Several of the methanogens were identified and the results indicate a succession of different methanogen species as the rumen develops.

- A molecular method for quantifying methanogens in DNA extracted from rumen samples using DNA extracts was established and confirmed and will be used to check effects of diet on methanogen levels.

- To obtain information on the relationship between fibre-degradation and methane formation, molecular methods were developed for quantifying major

fibre-degrading bacteria in rumen samples and successfully tested.

- Collaboration with Japanese scientists on molecular techniques for monitoring methanogens has been initiated. In the establishment phase, a Japanese scientist from Tsukuba visited in March 2005 while a reciprocal visit to Tsukuba occurred in June 2005.

Methanogen Genomics

In order to inhibit methanogens without affecting other useful microorganisms within the rumen, it is essential to have methanogen-specific targets for inhibitors. We have analysed *Methanobrevibactor. ruminantium* genome and have identified a subset of methanogen (archaeal)-specific features. Several strong candidate approaches have been identified but as yet none have been confirmed as a clear mitigation agent. The merging of the sequence data with the microbial information on methanogens will be a major focus of the ongoing work in this area. Progress this year includes

- Archaeal-specific genes within the M. ruminantium genome are being investigated as potential secondary targets for inhibition
- Cell surface proteins from sequence analysis are being investigated as potential targets for a methanogen vaccine
- Peptide nucleic acids are being investigated for potential inhibitory activity against M. ruminantium genes.
- Other M. ruminantium sequences identified from the M. ruminantium genome are being investigated for potential anti M. ruminantium activity.
- The completion of the genomic sequence of M. ruminantium was initiated.

Phage

Ruminant phages offer a real opportunity for inhibiting and reducing methanogen populations in the rumen. They have been shown to be active against methanogens but consistent activity and a effective delivery mechanism will need to be developed.

- Fingerprint profiles of total phage populations present in rumen samples from NZ sheep and cows were determined for the first time. This showed that phage populations in the rumen appear to bloom and change over short periods of time.
- Two methanogen–methanogen phage systems were established and tested using imported (non-rumen) methanogens and methano-phage. This confirmed that lytic enzymes rapidly degrade and destroy host methanogens.
- Efforts to isolate lytic and temperate phage, using molecular and non-molecular techniques, for use in phage therapy against methanogens in NZ ruminants are continuing.

Protozoa

In the rumen protozoa directly support methanogen growth and are a potential target in methane-abatement strategies. Because their role in ruminant digestion is not thought to be critical, strategies to reduce their populations may lead to reduced methane production with little or minimal effect on rumen digestion.

- Fifteen genes from protozoa predominant in NZ were cloned and sequenced to give the first information on the molecular phylogeny of protozoa in NZ ruminants and a phylogenetic tree showing inter-relationships was constructed.

- PCR primers were designed for use in studies in 2005/7 on methanogens attached to protozoa.

- Connections were made with a European Union consortium studying ruminal protozoa, and 5 species of protozoa imported for use in studies on methanogen-protozoa interactions.

Acetogens

These are regarded as a promising alternative sink for hydrogen in the rumen once a methanogen mitigation is applied. The relationship between acetogens and methanogens is not well understood but progress has been made in identifying the species involved.

- A joint study with Australia comparing acetogens in ruminants with those in kangaroos has been completed. All 4 kangaroo acetogens, but only 2 of 4 ruminal acetogens tested, utilised H2 at a high rate in in-vitro assays.

- Specific primers for quantifying a major acetogen species were designed and successfully tested and will be concluded in 2005/6.

METHANE MITIGATION EXPLOITING ANIMAL-TO-ANIMAL VARIATION

Earlier work has shown that methane emissions from different animals under the same conditions can vary significantly depending upon the animal and offers an opportunity for genetic selection for this trait. Genetic solution is a method that can be incorporated rapidly into many livestock systems. However for this to be adopted the trait of low methane production will need to demonstrate value over other selection traits. This years research included continuing measurements in a large scale Jersey-Friesian trial coupled with in depth studies of high and low emitting animals. Results were as follows:

Identifying Gene markers

The second year of large scale methane measurements in the BoviQuest herd has been completed and the analysis confirming or otherwise the opportunity for genetic selection in dairy cattle will be completed by September 2005. The number of methane measurements that has been collected over the two years of the trial (700+) has also presented the opportunity for the calculation of more accurate emission factors for grazing cattle, this will be followed for inclusion into the next national inventory calculation.

- We have shown that average methane emissions per cow/day and per Kg Dry Matter Intake (DMI) are consistent across years and are highly repeatable within years.

- The initial data demonstrates significant variation in methane production between animals.

- The initial analysis has shown that methane emissions were strongly and negatively correlated with milk production. If confirmed this will mean that selection for low methane production will not lead to lower milk production.

- Now the dataset is complete the genetic control of the trait can be estimated and a economic assessment of the trait developed.

- A repeat measurement of methane emission was undertaken using 9 cows obtained from the LIC QTL trial. The correlation (r) between emissions from animals grazing fresh pasture and the repeat measurement from the animals fed molassed-lucerne was 0.76 for absolute methane emission and 0.51 for methane emission per kg feed consumed.

- An indoor trial was carried out with the same 9 cows to identify mechanisms responsible for between-cow variation in methane emissions. Correlations of these specific CH_4 emissions with those at two previous measurements were nil.

- These results suggest that specific methane emissions either are highly variable for any animal or that the SF_6 technique may be too variable to identify low and high emitting characteristics.

- Methane was found in urine and faecal material but did not correlate with enteric methane emissions. The development of a simple test for high and low emitters will not be successful until high and low emitters can be reliably identified

PROOF-OF-FUNCTION: CLOVERS TO LOWER METHANE EMISSION.

Previously Caucasian clover in comparison to other clovers, has demonstrated low methane production in in-vitro assays compared to other clovers. Samples of Caucasian clover, both the commercially available and some unreleased series were collected from November 2004 through to April 2005 and evaluated with the *in vitro* rumen assay to determine a seasonal profile. In a follow up trial the best cultivars were to be tested in a grazing trial.

- The low methane production appears to correlate with higher soluble sugar and starch content.

- The cultivars showed significant differences at 12h in % accumulated-methane.

- In the assays, seasonal Caucasian clover cultivars were significantly different to ryegrass and white clover at 12h in % accumulated-methane.

- No strong indication of seasonal or location effects on methane production were observed.

- Because poor spring and summer growing conditions restricted the quantity of Caucasian clover available, in February 2005 a decision was made to delay the *in-vivo* testing of these three forages until late spring 2005.

IMPACT OF GRAIN OR OIL SUPPLEMENTATION ON METHANE PRODUCTION

This trial was undertaken primarily to measure the effect of dietary oils on rumen methane production. Oils derived from plant or animal sources are able to reduce rumen methane production by up to 80% in vitro (Fievez et al., 2003) and about 25% in vivo (e.g. Machmuller et al., 2000). Although the degree of methane suppression is variable, unsaturated oils or fats should always reduce methane production because the process of rumen bio-hydrogenation (creating harder fats) provides a sink for hydrogen ions derived from fermentation, reducing the amount of hydrogen available for methane production.

- This trial involved 30 cows grazing pasture ad libitum., 10 also received a grain supplement and 10 a protein and oil supplement (Oil). Methane production was measured over four consecutive days from all cows.

- The trial did not identify any significant differences for methane production between treatments which was in contrast to the previous trial carried out in 03/04.

- It is concluded that daily supplementation with fish and flaxseed oil for an extended period does not necessarily lower methane emissions, expressed in terms of feed DM intake, but oil supplements may lower voluntary feed intake. Future evaluation of oil or other dietary compounds for methane mitigation should be accompanied by measurements of rumen digestive physiology and microbiology.

METHANE INHIBITORS

The identification and application of chemicals that could inhibit methanogens directly offers a opportunity to "fast track" methane reduction by removing methanogens. To identify suitable chemicals a literature search was commissioned.

- The review was completed and a report provided to the PGGRC. The literature search was extended to chemical inhibitors of methane production from sludge and other anaerobic environments related to research in water quality.

- The review was sent to an International expert for an independent assessment.

- Some promising chemical inhibitors were identified but currently the consortium is considering business cases before any further progressing of options.

NITROUS OXIDE

DAIRY FARM NITROUS OXIDE EMISSIONS

A study was carried out to determine N_2O emission factors from cow urine and fertilizer urea following applications onto dairy farmlets. Understanding the extent and seasonal variation of N_2O emissions from cow urine and fertiliser is required to enable the development of best management practices in farm systems and Nitrogen management in the environment. The collection of this data also will enable more accurate calculation of the emission factors for N_2O and subsequent use in the national inventory calculations.

- N_2O emissions from a stand-off pad at Dexcel's Scott Farm were measured as an adjunct to the Resource Efficient Dairying (RED) trial . Data from this measurement will be incorporated with results from the farmlet study to estimate the total N_2O emission associated with "whole" farm systems, which include stand-off pads.

- N_2O emissions from the dairy farmlets at Dexcel's Scott Farm during the winter and spring seasons of 2004 and the summer and autumn seasons of 2005 were measured. The preliminary data indicates that both the use of maize silage and use of winter stand-off pads have potential for reducing N_2O emissions.

NITRIFICATION INHIBITORS

The application of nitrification inhibitors offers farmers an opportunity to not only reduce their N_2O emissions but also losses due to nitrate leaching and provide a opportunity to better utilise nitrogen in the farming system. These products are already available on the market but there effectiveness across differing soil conditions and nitrogen loads is not completely understood and is the focus of this strategy

Templeton Deep Sandy Soil Lysimeter Trial

- Application of *eco-n* to the large, deep sandy Templeton soil lysimeters significantly reduced N_2O emissions by over 55%.

- The applications of *eco-n* in May were similarly effective in reducing N_2O emissions irrespective of whether they were applied immediately after urine

application,or 10 days later.

Lismore Shallow Stony Silt Loam Soil Lysimeter Trial

- Application of *eco-n* at 7.5, 10 and 15 kg DCD/ha all reduced N_2O emissions by between 65 and 73% (confirming previous results) Lincoln University Dairy Farm Drainage Plot Trial

- Average data for the past 3 years shows that *eco-n* increased annual pasture yield in both the urine patch areas (23% increase) and the non-urine patch areas (21% increase).

- *Eco-n* reduced nitrate leaching losses from the large-scale on-farm Temuka drainage plots.

These results from the on-farm plots confirm the earlier lysimeter results.

Waikato Lysimeter Trial at Dexcel, Hamilton

A new lysimeter facility was successfully installed on the Scott Farm, Dexcel Hamilton to enable us to measure the effect of *eco-n* on direct and indirect nitrous oxide emissions and confirm any soil type differences

Mega-chamber lysimeter

The development of a large scale lysimeter 50m^2 which may better reflect the conditions in a farm paddock scale has commenced with some initial design features being tested. This has a number of engineering challenges to overcome, therefore the project will develop a series of prototype chambers with increasing size (1m^2, 10m^2, 50m^2)

3 THE SUCCESS OF THE RESEARCH

The research programme has developed as planned over the first three years of the consortium with effective progress being made across all research objectives.

Methane

Within methane research, the genomic sequence of *Methanobrevibacter ruminantium* has provided solid data on the potential sensitivities of a predominant methanogen. Microbial ecology studies have accelerated the microbiological understanding of the rumen and we now have a comprehensive set of tools to identify and monitor changes that may occur in the rumen when we apply mitigation technologies.

As yet no clear methane mitigation techniques have been confirmed, however promising information from the study of ruminant phage along with a detailed understanding of the methanogens biological pathways to produce methane has identified target approaches that will be developed in the next 12 months.

The forage approach has been delayed as the clover plots required were not advanced enough to graze the trial animals on. This work will be completed in the Spring. The opportunity to develop further forage options will be discussed with Pastoral Genomics as they have identified an

opportunity to incorporate some of the condensed tannin characteristics previously found to lead to lower methane production, into clover plants that are agronomically better to incorporate into farm systems.

The research to identify whether it is possible to use animal selection to reduce methane output has reached a critical point where after 2 years of data collection the analysis can be done to determine whether it will be feasible to search and identify genetic markers for this trait. The results of this analysis will be completed by September 2005. The further investigation into why livestock differ in there apparent emission rates has identified that the measurement variations between animals require further understanding and this will be the focus of the research in the next 12 months. An opportunity to investigate whether cattle previously selected for susceptibility to Bloat has arisen and will be investigated in the 05/06 year.

A review to identify possible methane inhibitors presented a comprehensive range of products but none have been selected for further development at this stage. The decision to pursue some of these as possibilities will only be done once a sound business case is assembled. In a unrelated piece of work studying compounds responsible for off flavour's a substance was identified that stopped methane production in a in-vitro assay. This substance has been identified and will be further investigated to determine its efficacy.

Nitrous Oxide

The research into the nitrification inhibitor *Eco-N* has continued to confirm its effectiveness in reducing Nitrous Oxide emissions and Nitrate leaching. Nitrification inhibitors are already available to producers but the uptake of them has been modest. A challenge for the future will be the development of appropriate policies that's recognise nitrification inhibitor use, these will be required if the advantage in reductions are to be realised. On-going research will include some evaluation of nitrification inhibitors effects on Sheep and Beef hill country situations.

The evaluation of N_2O emissions on the Dairy Farm systems trial at Dexcel has identified that there are management options for its mitigation available to farmers. The identification of the next steps to incorporate these into farm systems will be a product of the system analysis that will occur over the next few months.

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2. Nicholson MJ, Walker ND, Evans P, Joblin KN. 2005: The effect of diet on the populations of rumen methanogens and ciliate protozoa in red deer. *Gastrointestinal Function Meeting,* Chicago, USA.

3. Walker ND, Klieve AV, Joblin KN. 2004: Phage morphologies and population densities in the gut of herbivores grazing temperate pasture. *The New Phage Biology*, American Society for Microbiology Conference, Key Biscayne, Florida, USA.

4. Walker ND, Klieve, AV, Joblin KN. 2004: Impact of phage upon gut microbial ecosystems. *Microbes Outside the Square*, NZ Microbiology Society Conference, Palmerston North.

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5 FUNDING CONTRIBUTION 04/05

The funding listed here represents the direct funding invested through the PGGRC and does not account for the indirect cost of utilizing existing trials for research e.g. Boviquest Jersey – Friesian trial or the Resource efficient dairying (RED) projects.

Organisation	**Funding (GST excl)**
Meat and Wool NZ Ltd	390,000
Fonterra Ltd	350,000
Dairy InSight Inc.	450,000
Wrightson Ltd	125,000
DEEResearch Ltd	35,000
Fertilisers Manufacturers Research Association	90,000
Ravensdown Ltd	220,000
Foundation Research Science & Technology	1,618,000
Total	3,278,000

6 PARTNERSHIP INITIATIVES

International Collaborations
Connections were made with a European Union consortium studying ruminal protozoa, and 5 species of protozoa imported for use in studies on methanogen-protozoa interactions

A joint study between the Queensland Dept. of Primary Industries and Fisheries (QDPIF) and PGGRC comparing acetogens in ruminants with those in kangaroos has been completed and a report sent to the PGGRC

Collaboration with Japanese scientists on molecular techniques for monitoring methanogens has been initiated using funds obtained from the Aichi-leveraging fund of the Ministry of Foreign Affairs and Trade (MFAT) administered by NZ Trade and Enterprise. In the establishment phase, a Japanese scientist from the National Institute for Livestock and Grassland Science (NILGS) in Tsukuba visited in March 2005 with a reciprocal visit to Tsukuba in June 2005. Efforts are being made to continue the collaboration in 2005/6.

Consortium partner Meat & Wool New Zealand has recently joined the Australian Beef Cooperative Research Center (Beef CRC) as a core partner. The lowering of methane in beef cattle is one of the foci of the CRC and will be developed over the next seven years. This will offer the opportunity to work closely with Australian researchers in the field and if appropriate collaborate fully in on –going research.

National Activities

- Launched the PGGRC website (www.pggrc.co.nz)
- Mark Aspin presented the PGgRC research strategy as part of a panel discussion hosted by the Napier City council on climate change for its ratepayers. The other members of the panel were the Bill Bayfield, Climate Change office, Dr Gerald Rys, Ministry of Agriculture and Forestry and Richard Christie, Ravensdown Ltd.
- Mark Aspin attended the Australian - New Zealand Climate forum in Sydney hosted by the New Zealand and Australian governments and facilitated by the US based Pew Center for climate change.
- Mark Leslie presented to the energy conference at Te Papa
- Participated in the MethoNet and NZOnet workshops that focus on the inventory aspects of agricultural greenhouse gases.

- **Motu Economic and Public Policy Research Trust**

LAND USE, CLIMATE CHANGE AND KYOTO RESEARCH WORKSHOP's

The overall goal of this project is to build an integrated socio-economic/natural-science land-use model, and to use this to underpin analysis and design of policy for land-use and climate change issues. They aim is to build an empirically-based integrated model of the human and physical drivers, and environmental effects, of land-use change which predicts the dynamics of land-use change in New Zealand in a broad spatially and temporally explicit way. A first version of the model called Land Use in Rural New Zealand (LURNZ) has been produced.

7 HUMAN CAPITAL BUILDING INITIATIVES

PHD STUDENTS

Ben Vlamming

Commenced 2003

In his second year, the main area of his study being the measurement of methane produced by livestock. Main activities for the year are as follows:

- Involved in the planning and running of an animal trial in November and December 2004 for the measurement of SF6 and CH4 in cattle urine, and faecal material. Also recorded eating/ruminating behaviour by visual observation for 48 hours.

- A technique was been developed to extract and analyse CH4 and SF6 from faecal gas samples. Calculations have been developed to ascertain the quantities of both SF6 and CH4 being excreted per day in the trapped faecal gas. Small quantities of both SF6 are released but they are insignificant compared to that released from the mouth.

- In conjunction with NIWA a method was developed to measure CH4 and SF6 concentrations in urine and blood. Both SF6 and urine are present in small quantities in the urine but the quantities released per day are insignificant compared to that released from the mouth. The blood samples are still being analysed.

- An experiment was undertaken to ascertain if eating behaviour could be responsible for the variance between animals in CH4 production. A visual procedure was established for measuring eating, and ruminating behaviour was established after consultation with a scientists experienced in behavioural

measurements. The data are still being analysed.

- An analysis was undertaken of the methane database to ascertain if there was any relationship between SF6 permeation rate and absolute methane emissions. The analysis of the methane database was completed in conjunction with a statistician, and a paper written and submitted to the NZSAP. This was presented in May 2005. The conclusion reached was that in cattle there does appear to be a positive relationship between CH_4 emitted per kg DMI. The same relationship does not apply to sheep probably because of the low range of permeation rates in the tubes used for sheep

Natasha Swainson

Commenced June 2005

Received a Enterprise Scholarship from TEC with the industry sponsors being PGGRC, Elanco and DEEResarch, while the supporting research project is wholly funded by the consortium.

The aims of the associated research project is to gain a better understanding of how dietary manipulation affects methane emissions and nitrogen retention in sheep, cattle and deer, to investigate the potential of an existing cattle mitigation technology (sodium monensin) in sheep and to examine the impact of combining potential mitigation approaches. This research will identify the forage components that influence methane emissions and nitrogen retention and provide new information on mitigation technologies that may be employed under New Zealand's efficient farming systems

Sodium monensin, which affects both energy supply and protein utilisation has shown some potential as a possible GHG mitigation tool. In beef cattle fed concentrate based diets methane emissions have been reduced by up to 25% and nitrogen retention has been increased. New Zealand data collected on dairy cows in a PGGRC trials in 2003/04 on pasture indicated a more modest reduction of 10-12% in methane production. However, there is some controversy regarding the longevity of monensin effect and in addition, all data in the literature refer to the effects of monensin on cattle while in New Zealand, sheep are the biggest single source of methane emissions.

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SECTION II

OTHER AGRICULTURAL GREENHOUSE GAS RESEARCH

I CROWN FUNDED :

MINISTRY OF AGRICULTURE AND FORESTRY

Agricultural Inventory Research Programme 2004/2005

Introduction

Funded and coordinated by the Ministry of Agriculture and Forestry with the support of the Ministry for the Environment, Climate Change Office, and conducted by research institutes including Massey and Lincoln University, AgResearch, Landcare Research, Crop and Food, NIWA, and Dexcel. The total expenditure in 2004/5 was $500,000 inclusive of GST.

Nitrous Oxide Research Programmes

1) Hill country nitrous oxide emissions- extending the range of information and identifying key processes.

2) Soil compaction effects on the nitrous oxide emission factor EF3.

3) Documentation of nitrous oxide inventory methodology used for determining the national inventory emissions.

4) An initial investigation into indirect nitrous oxide fluxes from an agricultural stream.

5) Determination of water filled pore space measurement as a means of determining nitrous oxide emissions from New Zealand soils.

6) Review of research into nitrous oxide emission factor EF3 – emission rate from deposition of dung and urine onto pasture.

7) Paddock scale comparison and validation of nitrous oxide emission prediction methods.

8) Nitrous oxide research programme data archiving

9) Independent review of the nitrous oxide research programme - 2002 to 2005.

Methane Research Programme

1) Validating the SF6 technique using calorimetry. This forms part of NZ/ Australia climate change partnership programme.

2) Methane emissions from growing lambs – is the emission factor for lambs different?

3) Does afforestation of pasture increase methane uptake?

4) Use of satellite imagery to assess the time changes in mean nitrogen concentrations and digestibility values for incorporation into the national inventory.

5) Independent review of the methane research programme - 2002 to 2005.

NATIONAL INSTITUTE FOR WATER AND ATMOSPHERE (NIWA)

Drivers of variability in non-CO2 greenhouse gases

This project aims to quantify changes in the distribution and isotopic composition of methane and nitrous oxide in the background atmosphere of NZ, the Southern Ocean and Antarctica. The work includes international collaborations and seeks to understand past and current changes in the atmosphere and relate these to emissions and removal processes. High precision measurements of methane and nitrous oxide are made at Baring Head (near Wellington), in Antarctica, and on trans-Pacific ships to determine the gas concentrations and their variability. Gas samples extracted from polar ice cores are used to infer greenhouse gas concentrations over the last 2000 years, a period of rapid climate change, to provide comparisons with current changes and constrain our current estimates of greenhouse gas sources and sinks. This data is used in related research developing models to understand and predict future atmospheric changes.

The data are made available by FTP and are submitted to international databases such as the NOAA Global View Cooperative Data Centre in the USA, Global Atmospheric Watch programme, and the World Meteorological Organisation data storage centre in Japan.

Funding: **FRST $831k**
Timeframe Current contract expires June 2006, and will be extended to June 2007 by FRST.

Verification of agricultural greenhouse gas emissions

This project aims to develop techniques and methodologies for accurate greenhouse gas emission estimates that can confirm the efficacy of claimed ruminant emission mitigation methods. The research will develop new instruments for ruminant methane measurements based on emerging solid-state technologies. The work will use related research results on alternative tracers to SF6 carried out by NIWA as part of the AgResearch led *Global Processes in Terrestrial ecosystems* FRST programme.

Funding: **FRST $200k** (FRST/AgResearch $80k)
Timeframe Current contract expires June 2006, and will be extended to June 2007

Regional greenhouse gas emissions – methane (and nitrous oxide)

This project aims to improve information on NZ emissions of agricultural greenhouse gases on a range of spatial scales, from farm to landscape scales, providing a basis for better quantifying and managing greenhouse gas inventories. The research will apply a range of techniques including transects and vertical profile measurements of the gases, combined with models to estimate fluxes from the 'footprint' area.

(Related NIWA research is funded from the LandCare *Greenhouse gas emissions from the terrestrial biosphere* FRST programme. This research is developing methods to evaluate the smaller N2O fluxes, using micrometeorology techniques and has developed a method that uses CO2 fluxes as a tracer to derive the N2O fluxes.)

This research links directly to and is co-ordinated with the research of the MethaNet (and N2ONet) groups.

Funding: FRST $163k (FRST/LandCare $90k)
Timeframe Current contract expires June 2006, and will be extended to June 2007

LANDCARE RESEARCH

Work closely with other CRI's to underpin and strengthen New Zealand's ability to mitigate net emissions, and enable New Zealand to meet its obligations under the United Nations Framework Convention for Climate Change (UNFCCC) and the Kyoto Protocol.

Research projects themes

- Ways of reducing greenhouse gas emissions from land-based activities,
- New technologies to measure and monitor greenhouse gas emissions to internationally accepted levels of accuracy.

Reducing greenhouse gas emissions from the terrestrial biosphere
Determine how physical and biological processes on land regulate the production of New Zealand's major greenhouse gases-carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O),

- Identify and quantify New Zealand's terrestrial carbon sources and sinks
- Develop measurement and monitoring techniques to reduce uncertainty in New Zealand's greenhouse gas inventories.

Emissions estimation, and reduction of uncertainty in inventories:

- Measurement and modelling of CH_4 and N_2O at paddock scales,

Mitigation processes and strategies:

- Testing novel mitigation strategies
- Understanding of greenhouse gas emissions to enhance policy development and on-ground action to mitigate emissions.
- Use of intact soil cores to assess the effect of soil water content on nitrous oxide emissions from a poorly drained pasture soil
- Is soil a useful sink for methane?
- Modelling nitrous oxide emissions from New Zealand grazed pastures
- Nitrous oxide inventory: estimating a nitrous oxide emission factor for animal

urine

- Methane production from agriculture
- Reducing nitrous oxide flux from animal wastes
- Can we increase soil carbon to offset methane and nitrous oxide emissions from agriculture?
- Modelling nitrous oxide emissions from New Zealand's grazed pastures
- Refining the uncertainty in nitrous oxide emissions from New Zealand agricultural soils
- NzOnet contract research under contract to MAF, through the national research network NzOnet, we undertake collaborative research with other CRIs on methodology for abatement of agricultural greenhouse gas emissions.

II INDUSTRY FUNDED

DAIRY INSIGHT

2003/2004:Life-Cycle Analysis
Contractor: AgResearch Ltd

Determining the environmental performance of the New Zealand dairy industry compared with overseas industries by:

- Measuring the environmental performance of the New Zealand dairy industry using resource use indicators (land, energy, water) and pollutant indicators (greenhouse gases, eutrophication, acidification)
- Comparing the performance of the New Zealand Dairy Industry with other countries where comparable data has been produced (Australia, Denmark, France)

Funding: $56,250

Reducing Economic and Climate Change Impacts on Farm Energy Use
Contractor: Massey University

Reduction of energy consumption, direct costs and greenhouse gas emissions by:

- Developing a method for measuring total on-farm greenhouse gas emissions, energy consumption and costs to ascertain if farms are good candidates for energy efficiency improvement;
- Identifying the opportunities for development of new energy-efficient

technology for on-farm applications

- Disseminating a set of user-friendly energy efficiency recommendations to farm advisors, consultants and farmers that can be implemented at low cost

- Providing detailed end-use breakdown of electricity and time-of-use profiles that will enable alternative energy supply and end-use options to be analysed (e.g. solar water heating installations, time of use tariffs, etc.)

Funding $80,000

PASTORAL GENOMICS *(PG)*

The projects they are currently involved in that have a potential role in methane mitigation are summarised as follows:

- Gene discovery through the analysis of mutated genes in the model plant *Arabidopsis*. Gene(s) identified will be analysed in both clover and ryegrass for their effect on CT biosynthesis. We are currently in our fourth year of this research which is being carried out under contract with AgResearch.

- Gene discovery through the analysis of high Condensed tannins (CT) cotton fibres to identify the key genes involved in CT biosynthesis. This research has resulted in the identification of a gene that increases one aspect of CT biosynthesis, and another that increases DMACA staining (specific to CT's) in rice leaves. This work has been running for four years at ViaLactia and will be extended to ryegrass in the coming months.

- Using a non-GM technology ViaLactia is assessing the possibility of combining the genomes of ryegrass and a CT containing plant. This work is currently in its second year at Crop & Food.

- Using a similar non-GM technology as programme 3 PG is assessing the efficacy of combining the genomes of white clover and another clover that contains CT's in the leaf. This work is being carried out off shore and has been running for approx. 6 months.

- Under contract from PG AgResearch has an active gene discovery programme for genes involved in clover CT biosynthesis, and currently has several gene candidates in functional genomics. This programme has been running for approximately two years.

- PG also has a small programme in the area of high soluble carbohydrates in ryegrass. Through ViaLactia's relationship with IGER in the UK, PG has access to markers for marker assisted selection, linked to high soluble carbohydrate traits in ryegrass. A license for these tools for ryegrass breeding are currently available to NZ seed companies.

- In the past ViaLactia has identified that plants with high levels of stored

fumarate can have a significant effect on methane production from model rumen systems. This is not an area of active research for PG at this time.

- Through ViaLactia PG has identified a ryegrass gene that increases the total digestibility of ryegrass in rumen fluid. Whilst it is not certain, it is possible that this would have a beneficial effect on methane production by raising the overall ME that the cow can derive from that ryegrass.