Australian Agricultural Contributions to Greenhouse Gasses

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Executive Summary

Agriculture is reported to contribute around 16% of national greenhouse gas (GHG) emissions, accounting for 60% and 85% of total methane and nitrous oxide (N_2O) emissions, respectively. By 2012 Australia plans to have implemented a National Emissions Trading Scheme (NETS) and, while agriculture will be able to trade offsets, this scheme will initially not place a cap on agricultural emissions. Most States in Australia are also drafting Climate Change bills that will target a 60% reduction in GHG emissions by 2050, with an interim target of 20% by 2020 envisaged (in the case of Victoria). Clearly this will have an impact on the agricultural sector and the fertiliser industry would be advised to strategically prepare for this.

Methane is a high-energy source and represents a significant loss of energy from the production system that can and should be redirected back into production. Agricultural systems are also relatively inefficient in their use of N with between 20 to 60% of N inputs being lost from cropping and grazing systems, with some of this lost as N_2O.

Of the N excreted in urine 40 to 60% is lost either through ammonia volatilisation, nitrate leaching or denitrification (including N_2O). Extensive research has been conducted on using nitrification inhibitors as an abatement strategy to reduce these urinary losses from grazing systems. Emissions trading and GHG abatement targets are likely to change the economics of these products in the marketplace in future.

Research by the Greenhouse in Agriculture project, formerly under the CRC for Greenhouse Accounting, has shown that breeding, feeding and managing animal numbers are effective and potentially profitable strategies for reducing enteric methane emissions from ruminants. Likewise paying attention to the rate, source and timing of N fertiliser and only applying the N tactically, can both improve the efficiency of fertiliser use, but also reduce unnecessary N_2O emissions.

Introduction

Agriculture is reported to contribute around 16% of National greenhouse gas (GHG) emissions (Fig 1). The main GHGs emitted from farming systems are methane lost from rumen digestion (enteric) and nitrous oxide (N_2O) lost from nitrogen (N) fertilisers, animal excreta and soils. Agriculture accounts for 60% and 85% of Australia's total methane and N_2O emissions, respectively, both potent GHGs with global warming potentials many times that of carbon dioxide (CO_2). While most of the methane lost from agricultural systems comes from rumen fermentation (Fig 1), it is estimated that N fertiliser is responsible for 16% of N_2O emissions from agriculture while 21% is derived from N in animal excreta.

Policy context in Australia

While Australia has signed the Kyoto Protocol it has not been ratified into law, unlike the EU and New Zealand where they now have binding emission reduction targets. However, it is now clear that by 2012 Australia will have implemented a National Emissions Trading Scheme (NETS), irrespective of the outcome of the 2007 Federal election. At this initial stage a cap on emissions will not apply to the agricultural sector, but this sector can trade offsets to other sectors eg. tree plantings. As part of this NETS, emissions reporting and benchmarking will likely be required from all sectors. These developments are now being seen throughout the EU and closer to home in New Zealand. States in the USA are planning an ETS, while the Clean Air Act has now been applied to agriculture across the USA requiring reporting of emissions from agriculture.

In addition to the above, most States in Australia are drafting Climate Change bills that will target a 60% reduction in GHG emissions by 2050, with an interim target of 20% by 2020 (in the case of Victoria). Clearly this will have an impact on the agricultural sector and the fertiliser industry would be advised to strategically prepare for this.

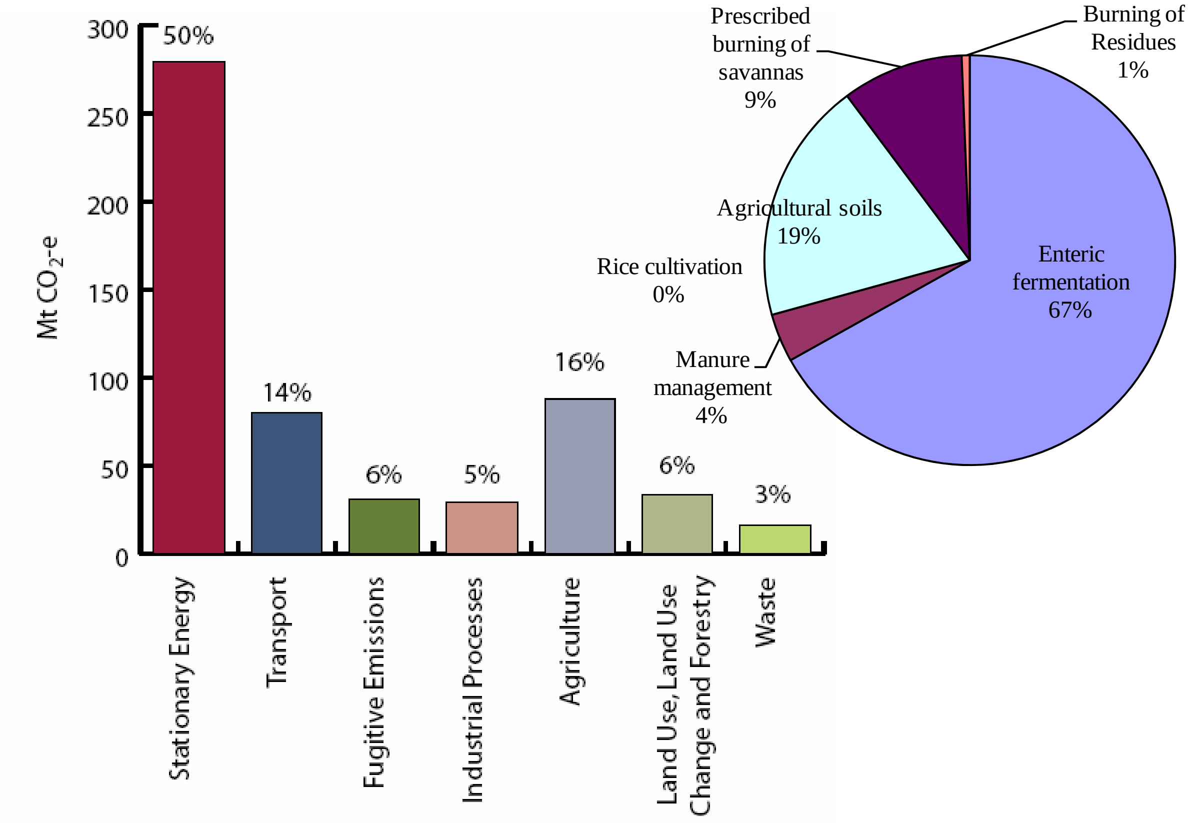


Figure 1. Australian national sectoral GHG emissions (left) and the apportionment of emissions within the agricultural sector (right), according to the 2005 National GHG Inventory.

Enteric methane

Methane is a significant greenhouse gas with 23 times the global warming potential of CO_2. Within the agricultural sector, methane is predominantly sourced from enteric fermentation in ruminants (Fig 1). In the rumen a group of microbes called methanogens are responsible for producing methane, utilising surplus hydrogen in the rumen to reduce CO_2 to produce methane. The methane produced is then largely belched and breathed out by the animal.

However, as methane gas is a high-energy source (see Table 1), this represents a significant loss of energy from the production system that can and should be redirected back into production. The key is therefore to provide another mechanism for reducing hydrogen levels in the rumen, otherwise normal digestion will be adversely affected and the energy savings will not be realised in improved production.

Table 1. Typical level of methane produced from enteric fermentation in the rumen of domestic stock and measures of animal production or energy lost as a result.

Animal Class	Methane (kg/year)	Equivalent grazing days of energy lost per animal	Potential km driven in 6-cylinder LPG car
Mature ewe	10 to 13	41 to 53	90 to 116
Beef steer	50 to 90	32 to 57	450 to 800
Dairy cow	90 to 146	24 to 38	800 to 1350

Breeding, Feeding and Animal Numbers

Methane research by the Greenhouse in Agriculture (GIA) project team has clearly identified differences between individual animals of up to 80% and, in most cases, this is linked to their productivity, indicating that breeding for more efficient animals results in less methane per unit of production. This research has also demonstrated that diet quality affects methane production, with animals on high quality spring pasture producing 29 to 37% less methane than those on poor quality summer pasture. Minimising the number of animals on the farm through earlier finishing (eg. improved feeding) or reducing unproductive animal numbers (eg. through extended lactation) also improves both the profitability and reduces unnecessary methane emissions.

Research by the GIA project team has also shown that dietary oils (eg. whole cotton seed) fed to dairy cattle in summer can reduce methane emissions by 12% (g/day) and 21% (g/kg Milk Solids), while profitably increasing milk solids by 16%. Likewise feeding tannin extracts from the black wattle was shown to reduce methane emissions by up to 29%, while also reducing urinary N excretion by up to 59%; the latter could be significant in reducing the N_2O and nitrate leaching from grazing systems.

Nitrous oxide

Nitrous oxide (N_2O) is a significant greenhouse gas with 297 times the global warming potential of CO_2. The exponential increase in the use of N fertilisers in Australia over the past 25 years has resulted in a corresponding increase in N_2O emissions attributed to agriculture. Nitrous oxide is primarily lost from agricultural soils as a result of cultivation, legumes, N fertilisers and animal excreta. Agricultural systems are relatively inefficient in their use of N, with between 20 to 60% of N inputs being lost from cropping and grazing systems. This wide range of losses also indicates room for efficiency improvements which also typically mean less N_2O emissions.

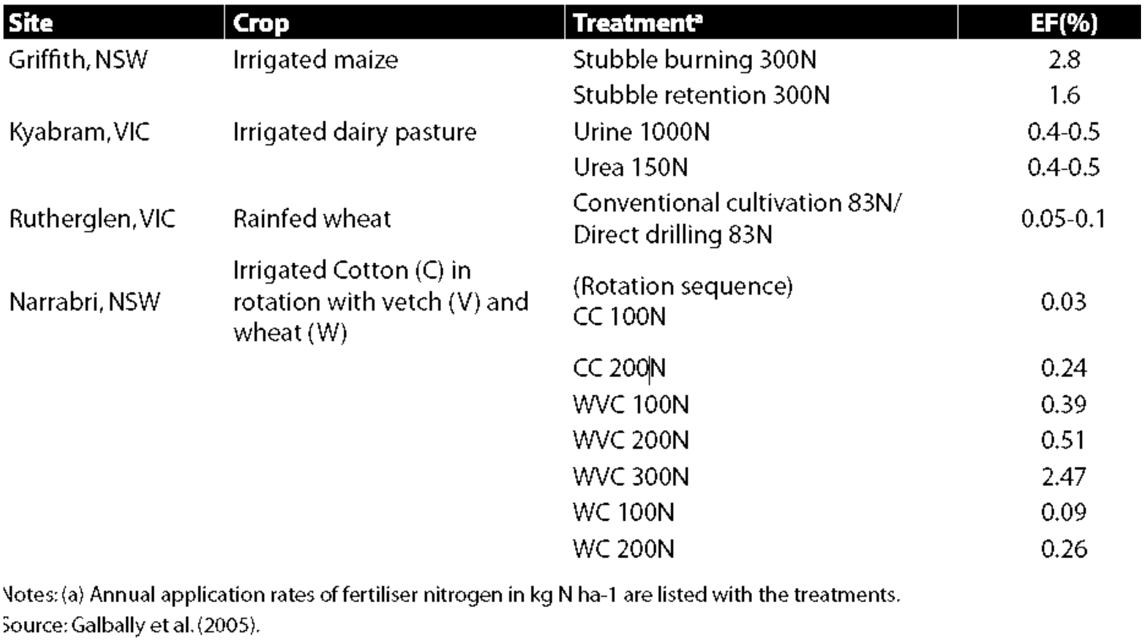
Nitrous oxide is mainly formed through denitrification; a process maximised in warm, anaerobic (wet) soil conditions with large amounts of nitrate and available carbon present. Nitrification can also be a minor source of N_2O in drier soils. *Any agricultural activity that inefficiently supplies N to the soil-plant system can therefore lead to large losses of N through a number of loss processes, including* N_2O*.*

Nitrous Oxide Emission Factors

The GIA research has now concluded that N_2O emissions from N fertiliser, applied to irrigated dairy pastures, maize and cotton and dryland winter wheat, appear much lower than the average emission factors from northern hemisphere studies, suggesting that a combination of our climate and soils, together with a more judicious use of N fertiliser results in lower greenhouse gas emissions.

The default emission factor (EF), recommended by the Intergovernmental Panel on Climate Change (IPCC) for national emissions reporting, assumed that 1.25% of all N fertiliser applied was lost as N_2O. The calculation of this default EF relied heavily on research conducted in the Northern Hemisphere where agricultural systems and environmental conditions are dissimilar to those in Australia. Revised and industry-based EFs reported by the GIA project are listed in Table 1. These low EFs reflect a combination of the climate and soils specific to Australian agriculture, but also demonstrated that the application of best management practices for N fertiliser can reduce N_2O emissions.

Table 1. N_2O emission factors from four agricultural systems in Australia.



Site	Crop	Treatment[a]	EF(%)
Griffith, NSW	Irrigated maize	Stubble burning 300N	2.8
		Stubble retention 300N	1.6
Kyabram, VIC	Irrigated dairy pasture	Urine 1000N	0.4-0.5
		Urea 150N	0.4-0.5
Rutherglen, VIC	Rainfed wheat	Conventional cultivation 83N/ Direct drilling 83N	0.05-0.1
Narrabri, NSW	Irrigated Cotton (C) in rotation with vetch (V) and wheat (W)	(Rotation sequence) CC 100N	0.03
		CC 200N	0.24
		WVC 100N	0.39
		WVC 200N	0.51
		WVC 300N	2.47
		WC 100N	0.09
		WC 200N	0.26

Notes: (a) Annual application rates of fertiliser nitrogen in kg N ha-1 are listed with the treatments.
Source: Galbally et al. (2005).

The 2005 National Greenhouse Gas Inventory now includes a series of revised EFs that are more industry-specific and appropriate to Australian climate and soils (Table 2). While this is only a reduction in ‘estimated’ emissions, *the relative contribution of N fertiliser use in agriculture to total greenhouse gas emissions has also been reduced.* This will have a positive impact on the perception of the environmental impact of agriculture.

Table 2. Revised country-specific emission factors from N fertiliser, included in the 2004 National Greenhouse Gas Inventory (data from Dr Mick Meyer, CSIRO MAR).

Production System	Emission Factor (% applied N)
Non-irrigated crop	0.3
Non-irrigated pasture	0.4
Irrigated pasture	0.4
Cotton	0.5
Sugarcane	1.25
Irrigated crop	2.1
Horticulture vegetables	2.1

Managing urinary N losses

In intensive grazing systems ruminants commonly excrete 75 to 80% of all the N they ingest from pasture. With urine being predominantly urea, the effective N fertiliser rate in a typical dairy cow urine patch can be 1000 to 1300 kg N/ha equivalent within the patch, taking 3 to 4 years to fully cover a pasture with at least one urine patch. It is not surprising therefore that, of the N excreted in urine, 40 to 60% is lost either through ammonia volatilisation, nitrate leaching or denitrification (including N_2O).

While nitrification and urease inhibitors have historically not seen widespread adoption, the emergence of emissions trading and GHG abatement targets is likely to change the economics of these products in the marketplace.

Extensive research has been conducted in New Zealand on using nitrification inhibitors as an abatement strategy to reduce these urinary losses from grazing systems. Research has shown DCD sprayed onto pasture can reduce N_2O emissions by between 60 and 80%, with increased pasture production of 15 to 25% possible. More recent research in New Zealand has also suggested that certain nitrification inhibitors can be passed out in the urine, thereby applying the inhibitor at the source of the excess N. Based on this evidence the New Zealand government is considering including recognition of the use of nitrification inhibitors in their National GHG Inventory, a move that will certainly increase the adoption and use of these products by farmers.

Other strategies identified for reducing urinary N losses include adding tannin in the diet (to bind surplus protein in the rumen), balancing protein to energy ratios in the diet, feeding salts to increase water intake (thus diluting urine) and grazing management (eg. stand off pads). However, most of these strategies still require further research before specific abatement can be claimed.

Best Management Practices (BMPs)

The research to date indicates that through improved feeding, breeding and management of livestock we can both reduce methane emissions and improve the profitability of our livestock production systems.

By paying attention to the rate, source and timing of N fertiliser and only applying the N tactically, we can both improve the efficiency of fertiliser use, but also reduce unnecessary N_2O emissions. Other BMPs would include using nitrification inhibitors, managing and conserving soil structure (eg. minimum tillage, compaction, stubble retention) together with soil water and irrigation management.

These best management practices have now been incorporated into various EMS tools and the Fertiliser Industry Federation of Australia's FERTCARE accreditation training program. A comprehensive list of the BMPs are also available on the GIA project web site at www.greenhouse.unimelb.edu.au.

Acknowledgements

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