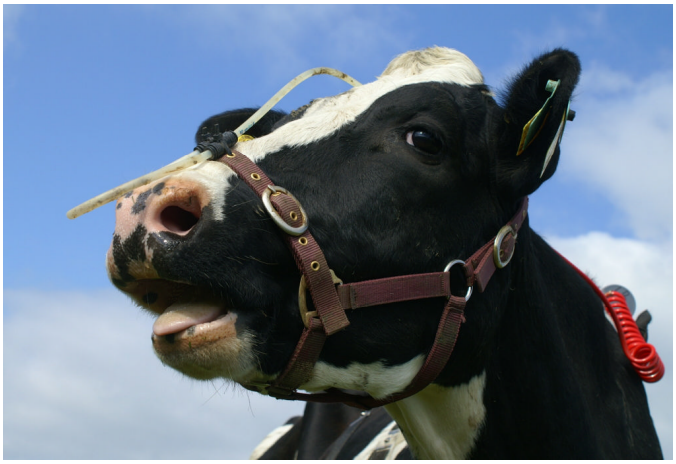
Project number: 5781
Funding source: Teagasc, DAFM
Date: July 2013
Project dates: Dec 2007 – Nov 2012

Mitigation strategies for methane emissions by dairy cows in Irish milk production systems



Key external stakeholders:

Irish dairy farmers; research institutes; grass and cattle breeding companies; DAFM

Practical implications for stakeholders:

- Cattle consuming high quality pasture can be expected to produce less methane. Enteric methane emissions per cow, per kg milk solids and per kg dry matter intake were lower when cows were offered pasture-only diets compared with those offered total mixed ration (TMR) or partial mixed ration (PMR) diets.
- There appears to be limited scope among conventional varieties of Perennial Ryegrass (PRG) to reduce methane output by grazing cattle. Methane emissions may be reduced, however, if water soluble carbohydrate concentration could be elevated.
- While white clover produced less methane compared with PRG, further research to determine its impact when included into PRG swards indicated little or no reduction in methane production.
- Dietary supplementation with specific dietary lipids will reduce methane emissions. However, when consideration is given to the cost and carbon footprint of including oils in the diet of ruminant animals, the benefit of this strategy is questionable.
- Jersey cows emitted less methane per day compared with Holstein-Friesian cows. Per unit intake or per unit output, however, no difference was found. Genetic analysis did indicate, however, that there exists the potential to mitigate enteric methane emissions through genetic selection. From a system perspective, cows originating from a balanced selection programme, such as the EBI, will reduce emissions per unit product compared with cows selected solely for milk production.

Main results:

- Cattle consuming high quality pasture can be expected to produce less methane. Less enteric methane emissions per cow, per kg milk solids and per kg dry matter intake resulted where cows were offered pasture only compared with TMR or PMR diets.
- Management strategies evaluated *in-vitro* using the 'Rusitec' (artificial rumen) showed limited or no potential to reduce enteric methane emissions by varying grass allowance, changing PRG varieties, including white clover or weed species in the pasture mix. Inclusion of specific dietary oils will reduce methane emissions but cost and carbon footprint implications may preclude real benefit.
- Genetic analysis provided evidence of the potential to mitigate enteric methane emissions through genetic selection. A further study demonstrated that cows with high feed conversion efficiency (FCE) had lower methane emissions per unit intake and per unit output.

Opportunity / Benefit:

GHG emissions per kg of milk solids can be reduced by 15% to 20% if several management strategies (improving animal performance, increasing N use efficiency, controlling emissions from manure storage, improving forage quality) are combined. The contribution of individual factors is, however, only small.

Collaborating Institutions:

UCD AFS; UCD BES; AFBI Hillsborough

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1. Project background:

Under the Kyoto Protocol, Ireland is required to limit total national greenhouse gas emissions. In January 2008 the EU Commission put forward a package of proposals that will deliver on the European Union's commitments to fight climate change and promote renewable energy up to 2020 and beyond. The package seeks to deliver a 20% reduction in total EU greenhouse gas emissions by 2020 (relative to 1990 levels) and at the same time increase to 20% the share of renewable energies in energy consumption. It has been estimated that enteric fermentation which naturally results in methane production accounts for 49% of the total GHG emissions associated with the average dairy unit in Ireland. The objective of this proposal is to investigate animal and dietary variables within the Irish pastoral system of milk production which could be manipulated to reduce enteric methane emissions by dairy cows.

2. Questions addressed by the project:

- Can the SF6 technique be established to evaluate methane mitigation strategies with relatively large numbers of cows across a range of component studies?
- Does grass quality influence methane emissions by grazing cattle?
- Do grazing cattle emit more or less methane compared with cattle offered TMR diets?
- Will concentrate supplementation increase or decrease methane emissions?
- Can grass be manipulated (breeding/management) to reduce enteric methane emissions?
- Is there potential to reduce enteric methane emissions by including white clover or other species into grazing swards?
- Is supplementation with dietary oils an effective means of reducing methane emissions?
- Is it possible to breed more environmentally friendly cattle, i.e., that will produce less methane?
- What level of reductions in methane emissions is possible using current technologies/knowledge?

3. The experimental studies:

The SF6 technique was established at Teagasc Moorepark. The relationship between grass (PRG cultivars), clover and weed species and methane production was assessed by *in-vitro* gas production and in an artificial rumen system. The effect of varying pasture quality, as well as the effects of TMR alone or as a supplement to pasture, oil supplementation and grass digestibility on methane emissions were evaluated at Teagasc Moorepark and UCD AFS. Dairy cow breed and genetic merit associations were evaluated. The SF6 technique was validated against respiration chamber measurements at AFBI Hillsborough. Data previously collected from studies using respiration chambers at AFBI were collated and statistically analysed to derive prediction coefficients for methane production by dairy cows offered different indoor type diets. The most promising findings from the above studies were incorporated into a whole farm systems/life cycle model to estimate potential effects on total greenhouse gas production from pastorally based dairy production systems.

4. Main results:

- Cows offered high quality (leafy) pasture produced 10% less methane (per day and per unit intake) compared with cows offered more mature (greater stem content) pasture.
- Cows offered TMR or PMR (partial diet as TMR) produced more methane (per cow and per unit output) compared to cows offered pasture-only diets.
- There appears to be limited scope among conventional varieties of Perennial Ryegrass (PRG) to reduce methane output by grazing cattle. However, if water soluble carbohydrate concentration could be elevated this would lead to lowered methane emissions and is seen as an avenue with potential for plant breeders to research.
- In the *in-vitro* studies, white clover produced less methane than grass, but as a mixture with grass resulted in higher methane emissions than from either PRG or WC individually.

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- Weeds commonly found in grassland were assessed for methane output and were generally found to reduce methane output. Given that most are of poor nutritive value they are not seen to offer potential to reduce enteric methanogenesis by grazing ruminants.
- A suite of molecular tools were optimised for the analysis of microbial communities (bacteria, protozoa and fungi) in the rumen. The profile of microbial communities was found to differ between pasture and TMR diets, where diets were supplemented with dietary oils, among cow breed.
- A comparison of breeds: Holstein-Friesian, Jersey and Jersey x Holstein-Friesian, showed that while Jersey cows emit less methane per day compared with Holstein-Friesian cows, per unit intake or per unit milk solids output, no difference was observed between the breed groups. A further component study evaluated cows identified as high and low FCE and found methane emissions per unit intake and per unit output were lower with the high FCE cows. Genetic analysis conducted using almost 3000 daily methane records (SF6 technique) from almost 300 individual cows indicated that there exists the potential to mitigate enteric methane emissions through genetic selection. The analysis demonstrated genetic variation, moderate heritability (0.14) and good repeatability (0.57). A modelling analysis demonstrated that cows selected through a balanced breeding programme (i.e. EBI) will reduce emissions per unit product compared with cows selected solely for milk production.
- Offering dietary oils containing high levels of polyunsaturated fatty acids will reduce the quantity of methane produced by lactating dairy cows offered concentrate supplementation at pasture. Linseed oil proved most potent. However, cost and carbon footprint implications would likely preclude meaningful benefit.
- Models developed at AFBI Hillsborough predict that methane output per unit intake can be reduced by increasing milk output, FCE, decreasing dietary fibre content and increasing feed quality.

5. Opportunity/Benefit:

In Ireland, grazing livestock are almost entirely dependant on grazed grass for 200-270 days of the year. It is incumbent upon the agricultural research community to develop strategies to reduce methane emissions from enteric fermentation under grazing. The results of this study clearly demonstrate that:

- Cattle consuming higher quality pasture will produce less enteric methane.
- Grass based systems are more favourable from an environmental foot print perspective compared with high input TMR based systems.
- There is potential to mitigate enteric methane emissions through genetic selection of animals.
- GHG emissions per unit product in dairy systems can be reduced by 15% to 20% if several management strategies (improving animal performance, increasing N use efficiency, controlling emissions from manure storage, improving forage quality) are combined.

6. Dissemination:

During the life time of this project, two open day events were held at Teagasc Moorepark. The objective of these events was to highlight research technologies that will increase farm profitability, post milk quotas, by instigating management practices that grow and utilise higher quantities of superior quality grass and achieve high animal performance over a long grazing season. The impact of best practice technology *vis-à-vis* its carbon footprint was highlighted at each board to impress upon stakeholders the role of technological improvement with regard to environment sustainability as well as economic prosperity. Papers from this study were also presented at the GGAA world GHG conference in Banff, Canada in October 2010. In total, 17 peer reviewed scientific articles, 44 technical (scientific) articles, as well as smaller numbers of popular press articles and discussion group visits to the experiments during the active project period. The research results were also disseminated via in-service training to Teagasc advisory staff annually.

Main publications:

Wims, C.M., Deighton, M.H., Lewis, E., O'Loughlin, B., Delaby, L., Boland, T.M. and O'Donovan, M. (2010). 'Effect of pre-grazing herbage mass on methane production, dry matter intake and milk production of grazing dairy cows during the mid season period' *Journal of Dairy Science* 93: 4976-4985.

O'Brien, D., Shalloo, L., Grainger, C., Buckley, F., Horan, B. and Wallace, M. (2010) 'The influence of strain of Holstein-Friesian cow and feeding system on greenhouse gas emissions from pastoral dairy farms' *Journal of Dairy Science* 93: 3390-3402.

Yan, T., Mayne, C.S., Gordon, F.G., Porter, M.G., Agnew, R.E., Patterson, D.C. and Ferris, C.P. (2010) 'Mitigation of enteric methane emissions through improving energy utilisation efficiency and animal productivity in lactating dairy cows' *Journal of Dairy Science* 93: 2630-2638.

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Popular publications:

Deighton, M.H. and O'Loughlin, B. (2011) 'Reducing dairy methane emissions' Moorepark 2011. Irish Dairying, Planning for 2015. Teagasc Moorepark Open Day, June 29, 2011.

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