Analysis of a New Zealand-specific no-cost option to reduce greenhouse gas emissions from dairy farms

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Contents

1. Executive Summary

The Ministry for Primary Industries contracted Motu to identify and address barriers to adoption of apparent 'no-cost' greenhouse gas (GHG) mitigation options on farms in New Zealand. As part of this project, AgResearch has conducted an assessment of current farm practices and farm management GHG mitigation options that are apparently no-cost. A qualitative assessment of the extent to which these options could be both practical and adoptable, and remain no-cost, was made. This report provides a more quantitative analysis of the GHG mitigation potential of one of the options: a lower input dairy system with a lower stocking rate with cows of superior breeding worth (BW).

A lower input system that carries fewer cows of greater genetic merit (high breeding worth (BW) and lower stocking rate (SR) led to reductions in total GHG emissions and GHG emissions intensity, ranging between 2-16% and 3-14%, respectively, with the reduction potential generally increasing with increasing milksolids (MS) production. These systems were more complex to run, required advanced management skills across the farming system and the profitability relative to current systems was highly dependent on the milk pay-out price. These systems had co-benefits of reduced nitrogen emissions to water, however further research and development is required to enable these systems to be adopted and to remain highly productive and profitable with the added management complexity.

2. Background

The Ministry for Primary Industries contracted Motu to identify and address barriers to adoption of apparent 'no-cost' GHG mitigation options on farms in New Zealand. In an earlier part of this project, AgResearch summarised currently available no-cost options to reduce GHG emissions intensity and/or absolute emissions on New Zealand dairy, sheep and beef farms (Table 1).

For each option, an initial assessment was made of whether or not these options are likely to be 'no-cost'. This was a qualitative assessment based on our understanding of the various options and their likely impact on the farming enterprise and recognises the complexity that farmer decision making brings to the final impact of mitigations on GHG emissions. 'No-cost' therefore refers not just to the cost of implementing the mitigation but also includes any gains that can be expected from its adoption. We also provided indications about whether or not no-cost options could be accounted for in the OVERSEER® nutrient budgeting model (hereafter referred to as OVERSEER).

From the options that were expected to be 'no-cost' and are able to be accounted for in OVERSEER, we selected an option for further analysis that was likely to have a significant impact on agricultural emissions. This option has been adopted on some farms already and the impacts on a farm's profitability and GHG emissions can be assessed for case-study farms.

The option selected to be examined in more detail was a lower-input dairy system with 'high breeding worth (BW) cows at a lower stocking rate'. High breeding worth cows have the genetic potential to produce more milk solids per lactation[1]. This short report provides a summary of the available information on the likely GHG mitigation potential and the feasibility of it being a 'no-cost' option.

Table 1: Summary of currently available GHG mitigation options for NZ pastoral farms and assessment of 'no-cost' and ability to be accounted for in OVERSEER.

Dairy farms	'No-cost'*	Accounted for in OVERSEER
High breeding worth (BW) cows/reduced stocking rate (SR)	Yes	Yes
Reduce replacement rates (fewer heifers)	Yes	Yes
Reduce N fertiliser use/ Replace some pasture with lower N feed	Yes	Yes
Apply N fertiliser with a urease inhibitor	No[1]	No
Apply N fertiliser with a nitrification inhibitor	No[1]	Yes
Apply N fertiliser or effluent when N_2O loss risk is lowest	Yes	No
Use stand-off pads when N_2O loss risk is highest	No[2]	Yes
Sheep/beef		
Increasing scanning percent – better genetics	No[3]	Yes
Increasing scanning percent – better feeding/feed utilisation	Yes	Yes
Increasing live-weight gain in lambs – better genetics	No[4]	Yes
Increasing live-weight gain in lambs – better feeding/feed utilisation	Yes	Yes
Hogget mating	No[5]	Yes
Changing stock classes (reducing beef cows)	No[6]	Yes
Planting forestry	No[7]	No

Notes: * Defined as maintaining or increasing the profitability of the farming enterprise.

[1]Assumes any pasture production benefits from N inhibitors are offset by application costs;

[2]Assumes capital investments and operational costs are required for stand-off pads or other off-pasture infrastructure;

[3]Assumes increased investment required for improved genetics and potential change in ewe numbers

[4]Assumes increased investment in genetics and systems changes to enable rapid live weight gain

[5]Assumes required systems changes, potentially reducing numbers of other stock classes.

[6]Assumes changing stock classes will involve transaction and capital costs, and greater trading market risks.

[7]Assumes investment is required to plant trees and potential loss of pastoral production from planted areas.

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[1] It should be noted that this system will incur a cost for transitioning to a herd with higher genetic merit will have transition cost. However, if this is achieved as part of the farm's animal replacement regime than no 'extra' costs are incurred. If there is a step change in higher BW animals then that incurs additional costs.

3. Methods

The 'high BW lower SR' management option for dairy farming systems was examined in a Canterbury farmlet study as part of the Pastoral 21 research programme (e.g. de Klein et al. 2016). It was also adopted on a Canterbury case study farm (Dynes et al. 2011; Ron Pellow, unpublished data). Furthermore, existing modelling has highlighted the potential for this option to reduce both GHG intensity and total emissions, because both the genetic potential of individual cows was higher and stocking rate was reduced (Beukes et al. 2010, 2011; de Klein et al. 2014; Smeaton et al. 2011; Vibart et al. 2015).

The analysis was therefore conducted using the following approaches:

- A literature review to summarise the GHG mitigation potential of the option as published in the journal papers and reports referenced above.
- An analysis of the Lincoln University Dairy Farm data.

4. Results and Discussion

4.1 GHG mitigation potential

Table 2 summarises the relevant information on the 'high BW/low SR' mitigation option.

Beukes et al. (2011) first modelled high BW animals at a lower SR as a potential GHG mitigation option using the Whole Farm Model, combined with OVERSEER®. Their analysis showed that, compared with a baseline farm, increasing BW while reducing stocking rates could reduce total GHG emissions and GHG emissions intensity by 2 and 13%, respectively (Table 2). Furthermore, milksolids (MS) production increased by 13% compared with the baseline farm. In another study, Beukes et al (2010) showed a greater reduction in total GHG emissions of 12% while the reduction in GHG emissions intensity remained similar to their 2011 study at 11%.

Scenario modelling of a higher BW/lower SR option for case study farms in five New Zealand dairy catchments also showed a reduction in GHG emissions from these farms (de Klein et al. 2014). The range of values reported reflected the differences in effectiveness between the regions where the farms are located due to contrasting levels of potential pasture production, and associated nitrogen fertiliser and supplementary feed inputs. Lower reductions were observed for the case study farm on the West Coast of the South Island and the highest reduction for the Waikato case study farm.

Similar results were found for a Canterbury case study farm (Dynes et al. 2011) where 'high BW/lower SR' reduced total GHG emissions and GHG emissions intensity by 14 and 6%, respectively (Table 2). However, MS production reduced by 8%.

Table 2: Summary of modelling and case-study farm results on the effect of using higher BW animals at a lower stocking rate on total GHG emissions, GHG emissions intensity, milksolids (MS) production, and profitability of NZ dairy farms. Results are presented as the percentage change from the base farm. The MS production of base farms are also included. Values in red represent non-favourable results.

		Change due to adoption of high BW/low SR options (% change from base farm)			
Reference	Milk production of base farm (kg MS/ha)	Milk solids production	Total GHG emissions	GHG emissions intensity	Profitability
Modelling studies					
Beukes et al. (2010)	1008	-1	-12	-11	n/a
Beukes et al. (2011)	1036	+13	-2	-13	n/a
de Klein et al. (2014)[a]					
Westland	671	0	-3	-3	n/a
Southland	989	0	-4	-4	n/a
Hamilton	1122	0	-8	-8	n/a
Canterbury	1134	0	-5	-5	n/a
Taranaki	1193	0	-5	-5	n/a
Dynes et al. (2011)	1323	-8	-14	-6	+10
Vibart et al. (2014)					
System 3 dairy farm	n/a	n/a	-5	n/a	+5 $6.50/kg MS
System 4 dairy farm	n/a	n/a	-13	n/a	+3 $6.50/kg MS
Case-study farms/farmlets					
Beukes et al. (2017 and unpubl. data)	1193	-2	-16	-14	-5 $6.10/kg MS
de Klein et al. (2016)[b]	2335	-24	-28	-6	+2 $6.10/kg MS[d]
LUDF (2017) year 1[c]	1740	-1	-15	-12	
LUDF (2017) year 2[c]	1740	+3	-11	-12	

[a] Results for case study farms in five NZ catchments; scenario modelling assumed milk production remained the same as for the baseline case study farm. [b] The baseline farm was a very high producing system with 5 cows/ha and MS production of 2335 kg MS/ha. [c] The baseline for this option is the average performance from the 5 years prior to adopting the high BW-lower SR management. Year 1 and Year 2 refer to year after adopting 'high BW/low SR' option. [d] From Chapman et al. (2017).

In the P21 research programme, the ‘high BW/low SR’ option was examined in a Canterbury farmlet system, which suggested a 28% reduction in total GHG emissions compared with the baseline, and a 6% reduction in GHG emissions intensity (de Klein et al. 2016). The baseline farm was a very high performing system producing 2335 kg MS/ha and with a stocking rate of 5 cows/ha, and the ‘high BW/low SR’ option resulted in a significant reduction in MS production of 24%. It should be noted, however, that the ‘high BW/low SR’ option not only changed its animal performance and stocking rate; N fertiliser inputs and grain supplementation were also reduced. The observed changes in GHG emissions are therefore due to a combination of options and cannot be attributed solely to the ‘high BW/low SR’ change. However, results from Vibart et al. (2015), where a range of mitigation options were sequentially incorporated, showed that the biggest change in GHG emissions occurred following adoption of a ‘high BW/low SR’ option. This can be explained from first principles, where reducing the number of grazing animals will result in less total methane emissions.

Excluding the results from de Klein et al. (2016), the reduction in total GHG emissions and GHG emissions intensity ranged between 2-16% and 3-14%, respectively, with the reduction potentials generally increasing with MS production.

A key conclusion of this analysis is that adoption of a high BW/low SR system will only achieve a reduction in GHG emissions if MS production is not (significantly) increased. In other words, the stocking rate should be sufficiently reduced to maintain (or slightly increase) milk production by using high BW animals and reducing fertiliser and supplementary feed inputs.

In addition, a limitation of this option is the availability of cows of very high BW. Farmers will need to ‘breed’ their way to this system or sell low BW cows and replace with high BW cows, which, because of their value, are seldom available on the market. Many farmers have limited potential to make culling decisions based on BW only, because of the need to cull cows for a range of other factors, including reproductive performance and herd health. In the short term, the potential for BW/low SR option to have widespread impact for the industry must not be ‘oversold’.

4.2 ‘No-cost’ potential

Regarding the ‘no-cost’ aspect of this option, this system can be highly profitable especially under the current average to low pay-out scenarios. These systems have lower costs of production due to lower cow numbers, animal health costs, labour savings, fertlliser inputs and supplement costs. The lower cost of production systems outperform high cost systems when payout is at or below long term averages. When payout is significantly above long term average, the higher stocking rate (and high input systems) tend to be more profitable.

To deliver higher MS production, cows must have the opportunity to maximise their energy intake (i.e. pasture intake) every day. This can be achieved by lowering the stocking rate which increases the pasture allowance per cow, enabling an increase in voluntary feed intake and the potential for cows to have a longer lactation due to higher body condition score, enabling a later dry-off date. Although a longer lactation may partly offset the gains in GHG reduction, the case-study farms still showed a reduction in GHG emissions from the farm system. Running a system with fewer cows per hectare is more complex than a higher stocking rate system as advanced grazing management skills are required to maintain high pasture quality throughout lactation. With a lower stocking rate it is more difficult to maintain post grazing residuals (1500 kg DM/ha) and higher individual cow intakes; there is a trade-off between maintaining high intakes and low residuals. Where residuals are not maintained near the optimum, increases in senescence of plant leaves increases the percentage of dead material in the sward, which decreases the metabolisable energy content of pasture. The maintenance of optimal pasture quality with lower stocking rate requires attention to daily pasture management, including returning the herd to the paddock for a short time after milking to achieve required residuals (labour cost), and potentially topping after grazing (labour and energy cost). These decisions are complex and require advanced management skills.

This option has potential for direct and spill-over benefits. The direct benefits include potential for less environmental impacts of the farm from a smaller herd. Many costs and stresses within a system are on a per cow basis so a smaller herd means less total animal health costs, fewer cows per labour unit, less time spent milking cows. Using fewer cows has the potential to reduce stress on labour, wear and tear on equipment and lanes. Spill over benefits include more leisure time for staff.

Smeaton et al. (2011) reported a modelling study to assess the impact of low emission management options. Their results suggested that low GHG systems that were also profitable always included one or more of the following attributes: high BW, lower SR, reduced N fertiliser use, and low replacement rates. They also concluded that it is possible to reduce GHG emissions intensity while increasing profitability, but that care should be taken when choosing a system to ensure the desired outcome is achieved.

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