Eliminating synthetic nitrogen fertiliser on dairy farms

Reductions in synthetic nitrogen fertiliser can be part of the combination of management practices associated with reducing on-farm emissions. These also include adjustments to supplementary feed use and stocking rates, which are tightly coupled to fertiliser use. Our analysis suggested on-farm practices can improve animal performance and thereby enable emissions reductions by reducing stocking rates while largely maintaining national production. However, additional emissions reductions could be achieved through more drastic cuts in or the elimination of synthetic nitrogen fertiliser use in dairying.[1] These emissions reductions would come through the reduction in direct nitrous oxide emissions from the fertiliser application and indirect reductions of nitrous oxide and methane as less pasture is grown and thereby consumed.

Eliminating synthetic nitrogen fertiliser on dairy farms would entail lower levels of production. The evidence regarding the economic impact of this is mixed. While some farms would certainly become less profitable, there is also evidence that some dairy farms could maintain or increase their profitability while eliminating synthetic nitrogen. The overall assessment suggests we should give more attention to this option in both the evidence and advice reports, but not adjust our modelling or emissions budgets.

Impact of eliminating synthetic N

In a study for the Fertiliser Association of New Zealand, Journeaux et al. (2020) modelled the potential impact of eliminating synthetic nitrogen fertilizer from different farming systems in Aotearoa. They prescribed that per cow production stayed constant while cow numbers reduced "until a feasible farm system was developed".[2] Table 1 shows the modelled reductions of animal numbers and GHG emissions in Northland, Waikato/Bay of Plenty, Taranaki, Southland, and Canterbury. Reductions are greatest in Canterbury where irrigation systems lead to a proportionally greater efficacy of nitrogen fertiliser and resulting emissions (Journeaux et al., 2020).

Table 1: Impact of eliminating synthetic nitrogen fertiliser for dairy farms (Journeaux et al., 2020)

	Reduction in cow numbers	kgMS production	GHG emissions reductions (CO2e)	Change in EBITDA ($)
Northland	-12%	-12%	-10%	-11%
Waikato/BOP	-12%	-12%	-14%	-11%
Taranaki	-14%	-14%	-19%	-14%
Canterbury	-24%	-26%	-31%	-44%
Southland	-15%	-15%	-17%	-8%

Reisinger et al. (2017) conducted a similar analysis for the Biological Emissions Reference Group but assumed production per animal decreases while animal numbers remain constant. The impacts of eliminating synthetic nitrogen fertiliser in their scenarios are shown in Table 2.

[1] There is limited emissions reduction potential for eliminating synthetic N use in other types of farming. Sheep, beef, and deer farms use very little nitrogen fertiliser, and only for strategic purposes. The potential is also limited in horticulture and arable farming because of the high levels of economic dependency on nitrogen fertiliser and the relatively small land areas mean the total emissions reduction potential is insignificant (Journeaux et al., 2020; Reisinger et al., 2017).

[2] The authors do not explain what they defined as a feasible farming system.

Table 2: Impact of eliminating synthetic nitrogen fertiliser for dairy farms (Reisinger et al., 2017)

	Reduction in cow numbers	kgMS production	GHG emissions reductions (CO2e)	Change in EBIT ($)
Northland	-	-9%	-11%	2%
Waikato/BOP	-	-13%	-10%	-24%
Taranaki	-	-14%	-13%	-13%
Canterbury	-	-4%	-6%	1%
Southland	-	-7%	-8%	0%

These are the most detailed recent studies of the potential impact of eliminating synthetic nitrogen fertiliser. They are consistent in showing significant reductions in both GHG emissions (6-31%) and milk production (4-26%).

The scale of this varies, however, with Journeaux et al (2020) suggesting an overall greater impact of on both production and emissions. The studies do not align in their assessment of the economic impact, although they are not directly comparable due to the choice of metric (EBIT and EBITDA). Journeaux et al. (2020) find significant negative impacts on EBITDA across all regions, particularly Canterbury. Reisinger et al. (2017) found much more variation, with small positive impacts on EBIT in Northland and Canterbury, little impact in Southland, and significant negative impacts in Waikatio/BOP and Taranaki. Reisinger et al. (2017)'s emissions reductions are also of a similar magnitude to those in an older study by Monaghan et al. (2008) who found eliminating synthetic N to result in GHG reductions of 5-14%. This also aligns with the percentage of dairy pasture growth assumed to come from synthetic N fertiliser in ENZ (~10%).

As for all interventions that affect production and inputs, the economic impact of eliminating synthetic nitrogen fertiliser is also significantly affected by export prices. Reisinger et al. (2020) note that reducing production and animal numbers is comparatively more profitable when milk solid prices are lower – although they do not state the milk price assumption for their eliminating nitrogen fertiliser scenarios. Glassey et al. (2013) found that a no-N dairy farm in the Waikato was more profitable than a control farm when milk prices were below $5.10 kg MS and less profitable when they were above (but still profitable overall). Journeaux et al. (2020) assumed a constant price of $6 kg MS in their analysis. In the 2019/2020 financial year, Fonterra's final farmgate milk price was $7.14 kg MS (Fonterra, 2021).

Organics and the potential of price premiums

A second important cost variable is the potential for farmers that eliminate synthetic nitrogen fertiliser use to attract a premium for their product. This could come through becoming a certified organic farm or achieving other emerging certifications that may be associated with an elimination of nitrogen fertiliser in the future such as for regenerative agriculture.[3] Recent premiums for organic milk have been strong, highlighting the potential for such approaches to overcome losses in profitability from lower input, lower production systems. The Fonterra organic milk price pay out for the FY19/20 season was $9.80 kg MS. Internationally, the relative farm gate premiums for organic milk are higher in many of our competitor countries (KPMG, 2018).

[3] Noting that an elimination of synthetic nitrogen fertiliser is not a strict requirement of regenerative agriculture, which is an outcomes-based rather than an input-based approach.

A study by the Our Land and Water National Science Challenge found that, compared to “average” system 3 dairy farms in Waikato and Southland, converting to organic could reduce emissions by 23-37% and increase profits by 42-67% (Lucci et al., 2019). This coincided with a reduction in milking cows of 16% and total milk solid productions of 9%. The organic premium was a theoretical one base on a metanalysis of research into consumer willingness-to-pay (Yang et al., 2020). Carroll and Daigneault (2019) assumed organic conversions in Aotearoa would result in animal numbers decreasing by 20% with a premium of 15%. This led to reductions in CH4 of 20%, N2O of 51%, and profit of 1%.

This research builds on earlier work such as the Massey University 10-year trial comparing organic to conventional dairy from 2001-2011. It showed organic dairy can be financially profitable in Aotearoa, while highlighting many of the complicating factors that need to managed including time to achieve certification (~3 years), animal health, and climate resilience (Shadbolt et al., 2011).

One possible limitation that could affect the potential of shifting to organic production is the availability of organic substitutes for synthetic fertilisers and other chemical inputs used on farms e.g. herbicides and pesticides. Journeaux et al. (2020), for example, suggests that there would be insufficient domestic non-chemical nitrogen fertiliser (e.g. compost and manure) for the whole fruit industry to go organic. It is not clear what the numbers would be for dairy farms; although it seems plausible that production of organic input substitutes could be increased. Importing is another option, the costs of which are unclear. Other barriers to organic expansion include limited organic processing infrastructure and concerns about organic production being incompatible with future technologies such as a methane inhibitor.

An Organic Products Bill is currently in its second reading in Parliament. It aims to increase consumer and business confidence in organics and facilitate their international trade. Aligning organic standards is consider one of the keys to unlocking further growth in the organic dairy industry (KPMG, 2018).

What this means for our advice?

There seems to be robust evidence to support the intuitive notion that eliminating synthetic nitrogen use would reduce agricultural emissions.

Eliminating synthetic fertiliser could also have significant co-benefits, particularly for water quality through reduced nitrogen leaching. Yang et al. (2020) found the converting to organic reduced nitrogen leaching by 17-24%, while Journeaux et al. (2020) found a range of 18-48% across the modelled regions, with the largest reductions in leaching in Canterbury. These ranges are similar to those found by Monaghan et al. (2008).

Two important sources of uncertainty and variation however, affect our ability to consider this in our analysis.

The first is the economic cost, as evidence of how eliminating N would affect farm relative profitability is varied, including across regions, and significantly affected by milk prices. The weight of evidence, however, suggests that it would be possible for many dairy farms to operate a profitably without N fertiliser. However, it is also likely true that many dairy farms could not. The relative profitability is also likely to be greatly affected by the ability to attract premiums, such as those accruing through organic certification. The strong organic premiums for dairy found in the literature and recent prices suggests that this could support the relative profitability of eliminating synthetic N fertiliser.

The second is additionality. Reductions in fertiliser use and animal numbers are both already envisioned to occur to a degree in our pathway as part of the package of on-farm management practices. However, they are considered as part of a package premised largely on improving animal performance to allow similar levels of production with fewer animals. The research on eliminating synthetic N fertiliser, however, is not premised on improving animal performance and is explicitly tied to reduced production. The outstanding question is to what degree could farmers improve animal performance to reduce emissions after already reducing animal numbers as a result of eliminating synthetic N fertiliser? It seems theoretically possible but is not yet underpinned by empirical evidence.

Successfully undertaking the changes involved with these approaches will be challenging and farmers will need support. Potential rebound effects will also need to be considered. Appropriate policies and incentives would need to be put in place to avoid rebounds effects (e.g. farmers replacing synthetic N fertiliser with supplementary feed to avoid reducing production) and ensure emissions reductions are achieved. This applies to all our agriculture recommendations i.e. the possible reductions in our path will not just “happen”: policies and incentives are needed.

Based on this analysis, it is recommended that we update our advice and evidence reports to better reflect the potential emissions reductions that could be achieved by removing synthetic N fertiliser. Updates should also reflect uncertainties and variation across farms regarding the impact on profitability, challenge of implementation, and the potential linkages to organic and other certifications that might significantly change this equation.

Options for inclusion:

1) **Evidence report:**

Update Chapter 4c (soon to be Chapter 7) on reducing emissions from agriculture to include the evidence presented here in the table and discussion of emissions reductions options.

2) **Advice report:**

Update the section regarding *Necessary action 11: Create options for alternative farming systems and practices*. Currently this section is focused on changing land use, e.g. from pastoral farming to horticulture or arable farming. It could be updated to talk more about more systemic changes to farming systems involving the current land uses, including the elimination of synthetic N fertiliser on dairy farms, which is a bigger transformation than the package of farm management improvements we imagine as part of *Time-critical necessary action 4: reduce biogenic agricultural emissions through on-farm efficiency and technologies*. This could be referenced in 1-2 additional paragraphs alongside organic and regenerative agriculture as alternative farming systems that may unlock deeper emissions reductions in the future through price premium incentives.

3) **Modelling**

Based on the evidence available at this stage it is not suggested that we make edits to the modelling. The uncertainties about additionality and cost remain too high and including it at a large scale may require additional thinking regarding the overall balance of effort across sectors. Given the time and resources available this is not recommended ahead of the 31 May deadline.

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