Burggraaf, V.T., Rennie, G.M., Edwards, P., Pinxterhuis, I. 2019. Meeting Nitrogen Discharge Allowances on a Rotorua dairy farm – a case study. In: *Nutrient loss mitigations for compliance in agriculture*. (Eds L.D. Currie and C.L. Christensen). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 32. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. 4 pages.

MEETING NITROGEN DISCHARGE ALLOWANCES ON A ROTORUA DAIRY FARM - A CASE STUDY

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Abstract

With regulatory requirements to reduce the amount of nitrogen (N) entering Lake Rotorua, we investigated mitigations, using the models Farmax and Overseer, for a dairy farm and its adjoining support land in the catchment. The base farm fed summer turnips, fodder beet, oats, palm kernel expeller (PKE) and pasture silage on the milking platform, with cows wintered on the support unit on pasture, kale and fodder beet. Leaching mitigations investigated were: removing crops from the milking platform whilst either A) reducing stocking rates; B) feeding additional PKE; C) replacing crops, PKE and pasture silage with purchased maize grain and maize silage (low N feed); or D) wintering cows on the milking platform (on pasture) at a reduced stocking rate. Under a milk price of $6/kg MS, D was the only scenario that increased profitability for the dairy platform (7%), whilst profit was reduced by 21, 0.3 and 7%, for A, B and C, respectively. Nitrate leaching was reduced by 9, 5, 19 and 23%, for A, B, C and D, respectively for the dairy and support land, compared to the base farm, with scenarios C and D meeting leaching targets for the farm.

Introduction

Under the National Policy Statement for Freshwater Management, Regional Councils throughout New Zealand are directed to maintain or improve water quality. In the Bay of Plenty, the Regional Council has set a sustainable annual nitrogen (N) load target for Lake Rotorua of 435 tonnes, which must be met by 2032 (http://www.rotorualakes.co.nz/plan-change-10). Landowners must demonstrate reductions in N losses (based on estimated outputs for the years 2001-2004) though Nutrient Management Plans and OVERSEER® nutrient budgets (Overseer).

Winter crops are widely used on New Zealand dairy farms, but when grazed *in situ*, they can pose a high N leaching risk, as they result in large amounts of N being excreted onto bare soil at a time when soils may be saturated (Shepherd *et al*. 2018). Use of fodder crops, with lower N concentrations, such as fodder beet (*Beta vulgaris* L.), may reduce urinary N excretion. Furthermore, following a winter crop with a catch crop, such as oats (*Avena sativa* L.), can remove much of the excreted nitrogen from the soil, further reducing N leaching (Carey *et al*. 2016), compared to leaving ground fallow until pasture establishment. As part of The Forages for Reduced Nitrate Leaching Programme, a monitor dairy farm was set up in Rotorua, which had an adjoining dry-stock unit used for supporting the dairy farm. As a consequence of learnings from the programme, the dairy farm adopted the use of fodder beet and oats, in place of kale, as part of its standard management.

The ability of catch crops, such as oats, to remove excess nitrogen from the soil after grazing of autumn and winter crops, is dependent on having low soil drainage before the plants are well established. As Rotorua has an average June-July rainfall of 237 mm, this still leaves the monitor farm susceptible to excessive leaching from autumn and winter grazed crops. To investigate potential options for further reductions in N leaching, after the adoption of fodder beet and oats, alternative feed, stocking rate and wintering scenarios were modelled in Overseer for the dairy and adjoining support land. The profitability of these scenarios were then modelled for the dairy platform only.

Methods

The monitor farm was a 369 ha dairy platform and adjoining 400 ha dry-stock unit used for sheep and beef cattle and dairy support, straddling both the Rotorua and Waikato catchments. The predominant soil type is a Haparangi silt loam, with 146 kg N/ha/year applied to pasture on the milking platform. Annual rainfall, as sourced from Overseer, was 1560 mm and the leaching allowance for the combined land area in the Rotorua catchment was 35 kg N/ha/year.

A baseline scenario was set up to represent the current management of the farm (Table 1). This included the use of fodder beet (grazed in April/May) oats (grazed in September) and turnips (grazed in February/March) on the milking platform, with kale and fodder beet grown on the dry-stock unit for wintering dairy cows. Supplements included home grown (on the milking platform) and bought pasture silage and a blend of palm kernel expeller (PKE) and dried distillers grain (DDG). All dairy replacements were grazed on the dry-stock unit, with cattle numbers in proportion to the size of the dairy herd, along with a mix of sheep and beef cattle, for which numbers remained constant across scenarios.

Mitigation scenarios to reduce N leaching were developed (Table 1) based on the farm management team's preferences, using systems that could be easily adopted on the farm and avoiding scenarios with high capital costs, such as stand-off pads.
All scenarios removed crops from the milking platform, whilst either:

A) Reducing stocking rate by 5%
B) Feeding additional PKE + DDG
C) Removing PKE + DDG and pasture silage and replacing it with low-N feeds (maize grain and silage)
D) Reducing stocking rate by 17%, wintering cows on the milking platform on pasture and not cropping on the dry-stock unit.

The dairy platform was modelled in Farmax Dairy, using a milk price of $6/kg MS and 2015/16 expenses. This included commercial grazing prices of $5/head/week to 9 months, $8/week to 21 months and $22/week for 22 months and older. Supplement prices were $201/t DM for pasture silage, $330/t for PKE + DDG, $400/t for maize grain and $300/t DM for maize silage. Crop establishment was costed at $1,500/ha for turnips and kale, $2,500/ha for fodder beet, $200/ha for oats, plus an additional $600/ha for returning crop paddocks to pasture. The costs of any crops used on the support block for wintering cows was added to the dairy economic analysis. Crop yields used in the modelling were those typically achieved on the farm: 17.2 t DM/ha for fodder beet, 3.5 t DM/ha for oats and 10.6 t DM/ha for turnips. Pasture production on the milking platform was 11.3 t DM/ha. N leaching across the entire land unit (dairy plus dry-stock) was modelled in Overseer (version 6.2.3), to ensure the impact of wintering cattle in the catchment was captured. The cost of additional feed grown by crops over the DM that would have grown over the same period if the paddocks were left in pasture was calculated based on the monthly pasture growth rates in the base Farmax file.

Results and discussion

Nitrate leaching was reduced by 9, 5, 19 and 23%, for scenarios A, B, C and D, respectively, compared to the base farm (Table 1). Reduced cropping, different wintering strategies, lower inputs of nitrogen in supplementary feeds and reduced stocking rates have been shown to reduce nitrate leaching in previous studies. The ability of each to meet nitrogen discharge allowances, however, is farm specific. This farm was able to reduce N leaching to its allowance of 35 kg N/ha in scenarios C and D. Meeting of leaching targets when support land is included will depend on how the support land is used. In this study, sheep and beef numbers remained the same across scenarios, so as to only capture the dairy farm management effects. There was potential, however, for increased sheep and beef stocking rates in scenarios A and D, to compensate for the reduction in dairy grazing. This could result in a less pronounced reduction in nitrate leaching for these scenarios. Alternatively, some of the extra feed could be conserved, the impact of which would depend on whether this was fed to stock within or outside the catchment.

Table 1. Modelled feed inputs, stocking rate, milk production and profit for a Rotorua dairy farm and leaching from the dairy farm and its adjoining support land.

	Base	A	B	C	D
Dairy cows 1st July	1105	1048	1105	1105	912
Stocking rate (cows/ha)	2.9	2.8	2.9	2.9	2.4
Winter off milking platform	✓	✓	✓	✓	✗
PKE (67%) + DDG (33%) mix (t)	760	588	947	✗	444
Pasture silage (t DM)	830	740	830	✗	630
Maize grain (t)	✗	✗	✗	595	✗
Maize silage (t DM)	✗	✗	✗	758	✗
Fodder beet/oats on milking platform (ha)	7	✗	✗	✗	✗
Turnips on milking platform (ha)	16	✗	✗	✗	✗
Fodder beet on support block (ha)	15	15	15	15	✗
Kale on support block (ha)	6	6	6	6	✗
Milksolids production (kg/cow)	362	353	362	361	357
Milksolids production (kg/ha)	1,056	978	1,056	1,055	854
Dairy farm working expenses ($/ha)[1]	5,682	5,384	5,667	5,732	4,284
Dairy platform operating profit ($/ha)[1]	1,040	823	1,037	971	1,113
N leaching (kg N/ha)[2]	43	39	41	35	33

[1]Includes costs of crops for wintering dairy cows in all scenarios except D.
[2]From dairy plus support land.

The profitability of these scenarios depends on multiple factors, including milk price, grazing, crop establishment and supplement costs, and the yield, quality and utilisation of crops relative to pasture. The cost of cropping was high for the additional DM yield achieved above what would have grown if the paddocks were left in pasture. This was calculated at approximately $300/t additional DM for fodder beet and $600/t additional DM for turnips. Hence, scenario B, where crops were replaced with bought in supplements, did not differ substantially in profit from the base scenario.

Only scenario D increased profitability of the milking platform (7%), while it was decreased by 21, 0.3 and 7% for scenarios A, B and C, respectively. The greater profit in scenario D came from a large reduction in farm working expenses (Table 1). This included reduced cropping and grazing costs as well as reduced wages, supplement, farm dairy and livestock costs due to a smaller herd size and hence, fewer dairy replacements. When the supporting grazing land is owned by the dairy farm, it is generally considered more cost-effective to winter cows off the dairy platform, but this study used commercial grazing prices for ease of comparisons with costs for other dairy farms. For scenario D, when considering profitability across both land units, the reduced costs associated with having fewer livestock and not growing winter crops outweighed the reduction in income from milk and livestock sales. For all scenarios, how any additional feed on the dry-stock unit, as a result of fewer dairy replacements and wintered cows, is used will also affect profit and leaching across both land units.

Conclusion

The Rotorua monitor farm's N discharge allowance was met by replacing crops and high-N supplements with low-N supplements, or removing crops and reducing stocking rates by 17%. The cost-effectiveness of N leaching mitigations will vary across farms, but there is potential to maintain or improve profit when meeting N discharge allowances.

Acknowledgements

Forages for Reduced Nitrate Leaching is a DairyNZ-led collaborative research programme aimed at reducing nitrate leaching through research into diverse pasture species and crops for dairy, arable and sheep and beef farms. The main funder is the Ministry of Business, Innovation and Employment, with co-funding from research partners DairyNZ, AgResearch, Plant & Food Research, Lincoln University, Foundation for Arable Research and Manaaki Whenua - Landcare Research. We also thank Parekarangi Trust, Jason Perry and Mark Johnston for participating in FRNL as a monitor farm, collecting farm data and making this available to research.

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