Williams I., Beukes P., Densley R, 2019. Dedicated cropping blocks within Dairy Farms: Using known mitigation strategies at a farm systems level. 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. 2 pages.

DEDICATED CROPPING BLOCKS WITHIN DAIRY FARMS: USING KNOWN MITIGATION STRATEGIES AT A FARM SYSTEMS LEVEL

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Abstract

With increasing pressure coming on dairy farmers to reduce the impact of dairying on the environment, there has been a number of trials completed looking at various mitigation strategies at a farm systems level (e.g. Pastoral 21). These mitigation strategies included feeding low protein feed to reduce Urinary Nitrogen (UN) output, reducing the amount of fertilizer N applied to pasture, standing animals off pasture during periods of high leaching risk, reducing stocking rate and increasing per cow output, applying effluent over a large proportion of the farm and more recently, the feeding of plantain.

Increasing numbers of farmers are growing maize silage on farm, using effluent collected from the cow yard and feed pad as the fertiliser source, and then feeding the silage back to the cows via the feed pad. The impact of these management strategies, while suspected as having a positive effect at reducing contaminant losses, has never been formally quantified in the New Zealand dairy system.

A simulation study using DairyNZ's Whole Farm Model (WFM) over the 2017/18 season compared a typical Waikato dairy farm (Current Farm (CF) 3.2 cows/ha, 125 kg N/ha on pasture, grass silage to fill feed gaps) with the Pastoral 21 Future Farm (FF, 2.6 cows/ha, 85kgN/ha, high genetic merit cows, some maize grain and a standoff pad). These farms were then compared to a potential low input, future farm (FFP, 3.2 cows/ha, feed pad, dedicated cropping block comprising 15% of the farm, growing maize silage in summer and annual ryegrass in winter, 85 kgN/ha on pasture). The model compared milk solids production, differences in N loss over the whole farm and the cropping block and N use efficiency. Results showed a potential 42% reduction in N leaching compared to CF (34 vs 59 kgN/ha), with an increase in milk production (1478 vs 1267 kg MS/ha) resulting in increased efficiency in N use (43.5 vs 21.5 kg MS/kg N leached). No economic analysis of either system was conducted.

Key Words: Nitrate leaching, N loss mitigation, Maize, Cropping blocks, Whole Farm Model

Introduction

Dairy farmers throughout New Zealand are facing significant cuts in the amount of contaminants leaving their farms (NPS-FM, 2014). In response to this, there has been a push to use various mitigation strategies seeking to reduce surplus nutrient losses from dairy farms.

Pastoral 21, a set of national farm systems trials, was initiated over a 5-year period (2011-2015) looking at evaluating various management strategies which would reduce the environmental impact of dairying while maintaining profitability (Beukes et al, 2017). As part of the Pastoral 21 programme, using the Whole Farm Model (WFM) (Beukes et al, 2008) DairyNZ modelled a typical Waikato dairy farm (Current Farm CF, 3.2 cows/ha, BW/PW 129/162, replacement rate 22%, 180 kg N/ha, no standoff) against a future farm system (Future Farm FF, 2.6 cows/ha, BW/PW 199/348, replacement rate 18%, 85 kg N/ha, standoff used March to June) for 4 seasons (21012-2015) (Beukes et al, 2017). The model predicted an annual N leaching loss for the future farm of 40-50% less than the current farm. However, less N also meant less pasture production, resulting in 2% less milk production for the future farm and 5% reduction in profit (Beukes et al, 2017). While the future farm included a standoff pad and the feeding of low protein supplements (imported maize grain) when needed, there was no feed pad included or cropping on farm.

Maize (Zea mays) is a high yielding (18-28 t DM/ha) crop that requires significant amount of nitrogen to grow. Every tonne of DM produced, requires 12kg of N so a 20 t DM/ha maize silage crop will remove 240 kg N/ha (Worku et al., 2007; Scharf et al., 2002). Maize silage is a low crude protein (7-8% CP) feed which can be used to dilute excess protein coming from pasture. Maize is a deep rooting plant with roots recorded at depths of 1.8 m (Kovacs et al., 1995; Kristiansen et al., 2004). The feeding of maize silage is considered as one of the mitigation strategies available to dairy farmers aimed at reducing N excreted and lost from their farms. However, when modelled, the extra feed-N brought onto the farm in the form of maize silage often negates the benefit of a reduction in CP in the cow's diet.

In a market survey conducted in 2013, 39% of Waikato farms had either a feedpad or some other kind of off paddock feeding system (Pioneer Brand Products, 2014). Approximately 75% of farmers using maize silage either grow some or all of their maize silage themselves (Pioneer Brand Products, 2014).

The objective of this study was to evaluate the effects of including a feed pad and a dedicated maize cropping block on production and N leaching of the FF system.

Method

The WFM was used to simulate a typical Waikato Farm (CF), a Future Farm (FF) as described in the Pastoral 21 trial, and Future Farm with a feedpad and a dedicated cropping block within the farm (FFP). Key model inputs are summarised in Table 1.

Table 1. Model inputs.

	Current Farm (CF)	Future Farm (FF)	Future Farm Plus (FFP)
Area (ha)	80	80	80
Stocking rate (cows/ha)	3.2	2.6	3.2
Feeding infrastructure	None	Standoff pad	Feedpad
Pasture N fertiliser (kg/ha)	125	85	85
Crop N fertiliser (kg/ha)			238 (Effluent only)
Cropping proportion(%)	0	0	15
Cow genetic merit (BW/PW)	129/162	199/348	199 /348
Replacement Rate (%)	22	18	18
Maize yield (t DM/ha)	NA	NA	23

The soil type used in the model is a Horotiu silt loam (Hewitt, 1998) with climate data from Ruakura 2017/18 season. The crop rotation on the FFP farm consisted of maize being direct drilled in October and harvested in April. Annual ryegrass was planted in early April, harvested by cutting, with the last cut in September before the block went back into maize. No N fertiliser other than effluent was applied to the crop block. All feed from the crop block was cut-and-carried and fed on the feed pad. Maize and ryegrass yields were climate-driven in both WFM and APSIM models, which run on daily input of actual climate data. The APSIM model was used to predict N leaching from the dedicated crop block. In APSIM the crop block was run over the period 2014-2018 with the same crop rotation (4 consecutive seasons) until total N in the soil profile was stable in the final year, 2017-18. Results of N leaching below 162 cm were only taken for the final year. The WFM was linked to APSIM using the Urine Patch Framework for predicting N leaching from pastures (see Beukes et al., 2011 for more details of this methodology). N leaching below pasture was recorded at 55 cm depth.

Results

The results of the simulations are shown in Table 2.

Table 2. Predicted results for the 2017/18 season. Current farm = CF, Future Farm = FF, Future Farm plus maize crop = FFP.

Scenario	Milk prod	Milk prod	Maize silage fed	Effluent N onto pasture	Effluent N onto crop	N leaching-pasture	N leaching-crop	N leaching-weighted average	N leaching reduction from CF	N efficiency
	kg MS/cow	kg MS/ha	kg DM/cow	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	%	kg MS/kg N leached
CF	392	1267	152	24	NA	59	NA	59		21.5
FF	480	1256	179	22	NA	35	NA	35	41	35.9
FFP	458	1478	838	0	238	38	9	34	42	43.5

Results showed that the addition of the cropping had the benefit of lifting production per hectare for the FFP scenario by 211 kg MS/ha over CF and 222 kg MS/ha over the FF scenario. This was due to the FFP having more cows per hectare than the FF (3.2 vs 2.6) but producing slightly less milksolids per cow (458 vs 480) and the FFP having the same SR as the CF but producing significantly more milk/cow (458 vs 392) because of better genetics.

Nitrogen loss from pasture for the 3 farms was highest for CF (59 kg N/ha) and lowest for the FF (35 kg N/ha) and FFP being slightly higher at 38 kg N/ha. Because of the ability of the maize to capture more of the recycled N and keep it on the farm, more N cycled through the FFP herd and some of it got deposited on the pastures resulting in slightly higher leaching. In the case of FFP the feedpad contributed to the recycling because of the time cows spent on this structure and the large proportion of UN recycled to the pond (assumed 84%).

The cropping block had a low 9 kg N loss per hectare. This would be due to the use of effluent to grow the crop, the assumed stable state of the soil with very little extra mineralization, the deep rooting nature of maize (leaching below 162 cm), winter growth of the catch crop, and the absence of grazing animals on the block.

The dilution effect of the cropping block on the overall farm leaching meant that the FFP had the lowest N loss (34 kg N/ha) compared to FF (35 kg N/ha) and CF (59 kg N/ha). Both the FF and the FFP leached approximately 40% less N than the CF.

Nitrogen Use Efficiency (NUE, kg N leached/kg MS produced) was highest for FFP (43.5), middle for FF (35.9) and lowest for CF (21.5).

Discussion

Our results show that using a dedicated cropping block to produce a high yielding, low-protein feed in the form of maize silage and a high winter yielding feed in the form of annual ryegrass silage, increased feed available per hectare. This extra feed per hectare on the FFP enabled the model to maintain SR at 3.2 cows/ha while producing more milk per cow because of the higher genetic merit in the FF systems. The overall result meant that there was a significant lift in the amount of milksolids produced per hectare with 40% less N lost to leaching. There was also no extra N lost per hectare but significantly more milk/ha (18%)

when compared to the FF. The N use efficiency of the FFP system shows that a dedicated crop block with maize followed by a catch crop (e.g. annual ryegrass in this case) can recycle more N within the farm gate, with more N going out as product, and less N per unit product going into the environment. This positive outcome for a maize block on the milking platform in the Waikato region can probably be generalised with the caveats that the crop is rotated on the same block so no new N mineralisation, the crop is established with minimal cultivation, only effluent N is recycled onto the crop, yields are average to good, and the catch crop is harvested and not grazed in winter.

The critique of the FF in the Pastoral 21 programme was the 2% reduction in milk production combined with the extra capital cost of the standoff facility and the bought in maize grain, resulting in a 5% reduction in profit. By increasing the amount of feed produced per hectare using 15% of the dairy platform as a cropping unit, lifted milk production per hectare by approximately 18%. While there was no economic analysis completed as part of the model, it is possible that the extra costs of growing and feeding the maize along with the capital cost of the feed pad and tractor/feed out wagon will be covered by the extra milk produced. A full analysis of this hypothesis is needed.

Conclusions

A continuously cropped block comprising 15% of the dairy platform, growing maize silage in summer and annual ryegrass in winter with the feed being fed to the cows on a feedpad, and effluent collected to be used as the fertiliser source, appears to have promise at solving the problem of reducing N loss through leaching while increasing milk production. Because the model was run for only one season on one soil type, it would dangerous at this stage to extrapolate the data beyond the parameters of the model. More simulations are obviously needed across different growing conditions and soil types and need to include economics.

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