Northland Dairy Development Trust
&
Northland Agricultural Research Farm

'Future Farm Systems' Field Day

7th June 2023

Project funders

Hine Rangi Trust

Thanks also to our sponsors and supporters for their continued support

Visit the Northland Dairy Development Trust website for further information and updates from these projects

www.nddt.nz

Follow us on Facebook – Northland Dairy Development Trust

For further information contact:
Chris Boom – chris.boom@agfirst.co.nz or Kim Robinson – kim.robinson@agfirst.co.nz

These on-farm trials are being run by the Northland Dairy Development Trust (NDDT) in conjunction with the Northland Agricultural Research Farm (NARF). The projects are funded by DairyNZ, Ministry of Primary Industries (Sustainable Farming Fund & Sustainable Food and Fibre Futures) and Hine Rangi Trust with support from commercial sponsors.

Future Dairy Farm Systems for Northland Project

Chris Boom and Kim Robinson

Summary

This study compares a typical Northland dairy farm system (**Current Farm** – kikuyu/ryegrass pastures, 3.1 cows/ha, up to 190 kg N/ha applied) with a farm that has 74% of land in tall fescue/cocksfoot-based pastures (**Alternative Pastures Farm** - 3.1 cows/ha, up to 190 kg N/ha) and a farm designed to have significantly reduced greenhouse gas (GHG) emissions (**Low Emissions Farm** – kikuyu/ryegrass pastures, 2.2 cows/ha, no nitrogen applied).

Two seasons of the 4-year trial have now been completed. Unfortunately, in February 2023 cyclone Gabrielle flooded most of the farm causing widespread pasture damage and the trial had to be stopped for the remainder of the second season. The results presented for the 2022/23 season are actual results until 14 February, then estimated numbers based on modelling the remainder of the season (assuming actual rainfall without the impact of flooding). Damaged pastures have since been resown and the trial recommenced on 1st May 2023.

The key features of the trial's second year were a wet summer, strong clover growth, lower milk price and higher input costs. The drier summer advantaged the kikuyu-based pasture system (Current Farm) while the wetter summer advantaged the alternative species pasture system (Alternative Pastures Farm). Milk production on the lower stocked Low Emissions Farm was higher in the 2022/23 season compared to the 2021/22 season, likely due to higher clover content in pastures and better grazing management strategies being employed.

Financial analysis of the farms, using actual milk price for each season, shows a significant change in relative profitability between years. In 2022/23, the Alternative Pastures Farm was the most profitable, followed by the Low Emissions Farm, then the Current Farm. The relative increase in profit of the Low Emissions Farm has been driven by better production, lower milk price, and significant inflation in input costs having a greater impact on the higher input farms.

	Milk Solids kg/ha		Farm Operating Profit $/ha	
	2021/22	**2022/23**	**2021/22**	**2022/23**
Current Farm	1,284	1,204	$5,040	$1,912
Alternative Pastures Farm	1,213	1,269	$4,786	$2,707
Low Emissions Farm	794	910	$3,021	$2,282

When compared to the Current Farm, the Low Emissions Farm had a 29% reduction in methane emissions/ha, a 44% reduction in nitrous oxide emissions/ha, and a 16% reduction in methane emissions/kg milk solids produced.

This study has provided results under two contrasting seasons. So far, there is no clear advantage (or disadvantage) to replacing kikuyu/Italian ryegrass-based pastures with tall fescue/cocksfoot

based pastures. Reducing stocking rate and applying no nitrogen fertiliser, in order to reduce green house gas emissions, resulted in a significant reduction in farm profit in the first season, however it seems the system stabilised in the second season, somewhat due to better management practices. Two to three further years of this study will allow testing of these regimes over further variable climatic conditions and display any compounding treatment effects over time.

Background

Northland farm systems are at the forefront of the effects of a warming climate and demonstrate the challenges that the rest of New Zealand will experience over time. In Northland, ryegrass persistence is relatively poor, rust and pest damage are increasing and regression to kikuyu often occurs within two to three years after sowing new ryegrass pastures. Kikuyu is productive during summer/autumn, however it is has poorer nutritive value, is difficult to manage and has low winter/spring growth. Farmers are looking for alternative pasture species which may be more persistent and resilient in the face of climate change.

We are also being encouraged to lower GHG emissions on dairy farms. There is plenty of modelling information, however farmers are uncertain as to whether the strategies to reduce emissions are physically or financially sustainable, particularly the lowering of stocking rate on pastures containing kikuyu.

This project is conducting a farm systems trial at NARF to test and compare three farm systems which may be used in the future to mitigate and adapt to the effects of a warming climate.

Trial Design

This project compares three farm systems:

1. **Current farm** (Red) – existing ryegrass/kikuyu pasture farm system with imported feed (likely PKE) to fill feed deficits. Stocking rate 3.1 cows/ha and up to 190 kg applied N/ha
2. **Alternative Pastures farm** (Blue) – 75% of pastures in alternative species to ryegrass/kikuyu - including fescue, cocksfoot, legumes & herbs with imported feed (PKE) to fill feed deficits. Stocking rate 3.1 cows/ha and up to 190 kg applied N/ha
3. **Low Emissions farm** (Green) – existing ryegrass/kikuyu pasture farm system that targets a 25% reduction in methane emissions and 50% reduction in nitrous oxide emissions (compared to the Current farm). Stocking rate 2.2 cows/ha, no nitrogen application. Little or no imported feed

This farm systems trial commenced June 2021 and will run for at least four years to test these systems under a range of climatic conditions. Trial measures capture pasture and milk production, milk composition, profit, and people (labour input and management difficulty) data on the three systems.

Introduction of New Pastures

The Alternative Pastures Farm was set up by sowing 74% of the farm area during 2020 and 2021. Species sown were tall fescue, cocksfoot, white and red clovers and chicory. Plantain and Persian clover have been added in some paddocks.

Establishment of pastures sown in 2020 was excellent, whereas establishment of 2021 sown pastures was variable mainly due to competition from poa annua. As a result, 17% of the area was resown in autumn 2022, again with variable success.

Costs of the pasture introduction were similar across the three years, averaging $1,138/ha. This includes tractor and man hours associated with this introduction as well as contractor costs for drilling.

The other two farms (Current Farm and Low Emissions Farm), and the 26% of the Alternative Pastures Farm that was not sown in new species, have older pastures with approximately 70% of the area having kikuyu presence. All kikuyu-based paddocks on all farms are mulched every autumn and drilled with Italian ryegrass. This provides control of kikuyu stolon and also a winter/spring active ryegrass to complement the summer/autumn active kikuyu.

Cyclone Impact and Recovery

Around 90% of the farm flooded during Cyclone Gabrielle in February 2023. Most of the paddocks were under water for 3 - 5 days. On around 60% of the area within each farm, all temperate grasses, including ryegrass, fescue and cocksfoot, herbs and clovers died. The individual farm structure was disbanded and not reinstated until 1st May.

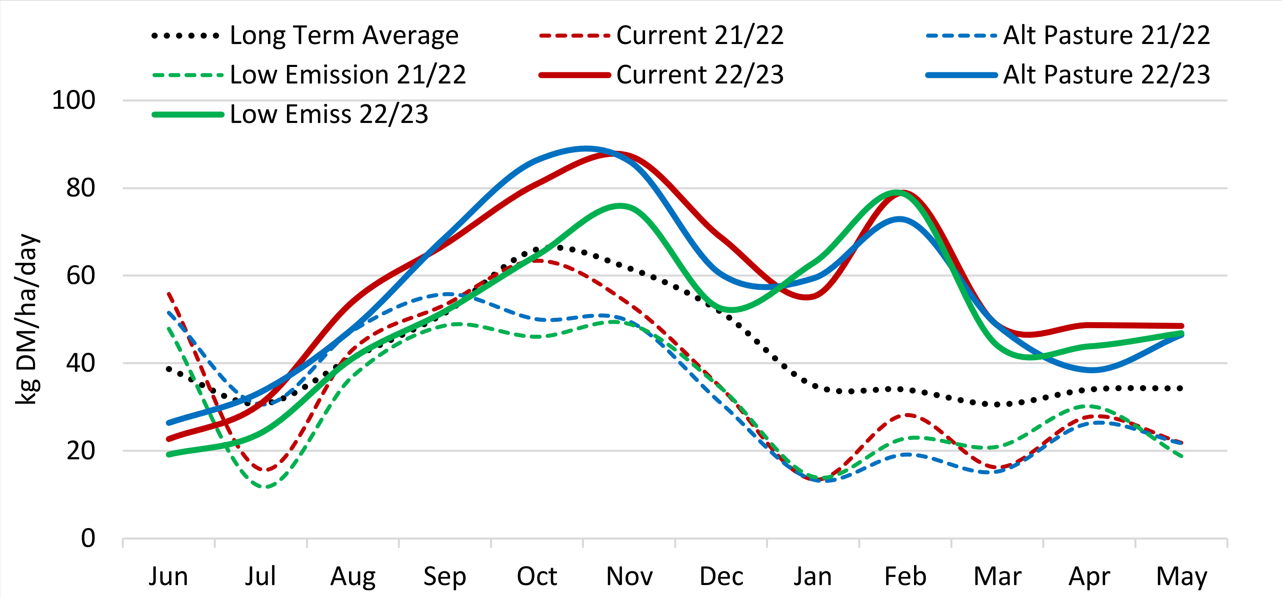
Areas of long or silted pasture were mown and removed by baling or mulching. Kikuyu bounced back quickly and provided good quality leafy feed for the herd through March and April.

During March and April, approximately 60% of the area on the Alternative Pastures Farm was resown back into tall fescue/cocksfoot-based pastures. Following mulching, Italian ryegrass has been drilled into kikuyu-based areas as is our normal autumn kikuyu management. Re-sown pastures have established well resulting in farms being well set up for the 2023/24 season.

Pasture Growth

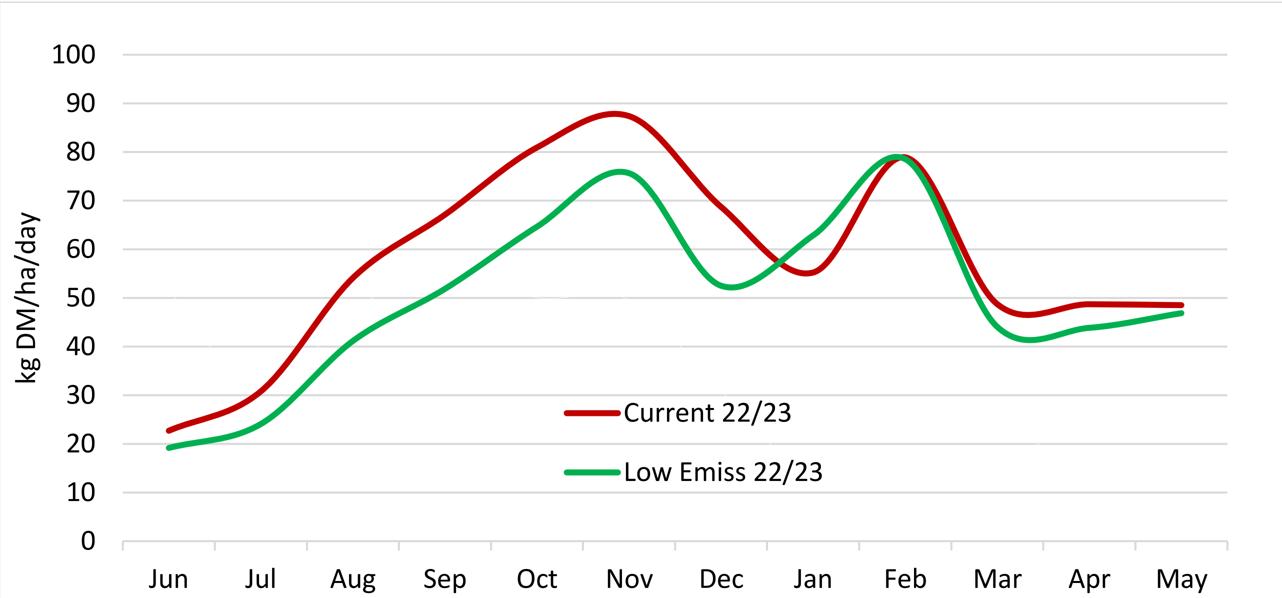
Figure 1 shows the pasture growth differences between these pastures as calculated by weekly platemeter assessments. During the 2022/23 season, regular rainfall supported strong summer growth and the farm was on track to grow approximately 20 t DM/ha on the Current and Alternative Pastures Farms. This compares to the long-term average of 15.4 t DM/ha, and 13.0 t DM/ha during the 2021/22 season.

Figure 1. *Pasture growth rates for 2021/22 and 2022/23 seasons as calculated by pre – post grazing platemeter assessments.*



The difference between the Current Farm and the Low Emissions Farm, as shown in figure 2, shows the impact of nitrogen and indicates the Current Farm grew 2,648 kg DM/ha more than the Low Emissions farm. With 171 kg N/ha applied to the Current farm during this period, this calculates to a full farm systems nitrogen response of 15.5 kg DM/kg N. This is much higher than last season (at 8.0 kg DM/kg N), likely due to better summer rainfall extending the N response well into summer.

Figure 2. *Pasture growth rates for 2022/23 season showing N effect between Current and Low Emissions Farms (with and without nitrogen).*

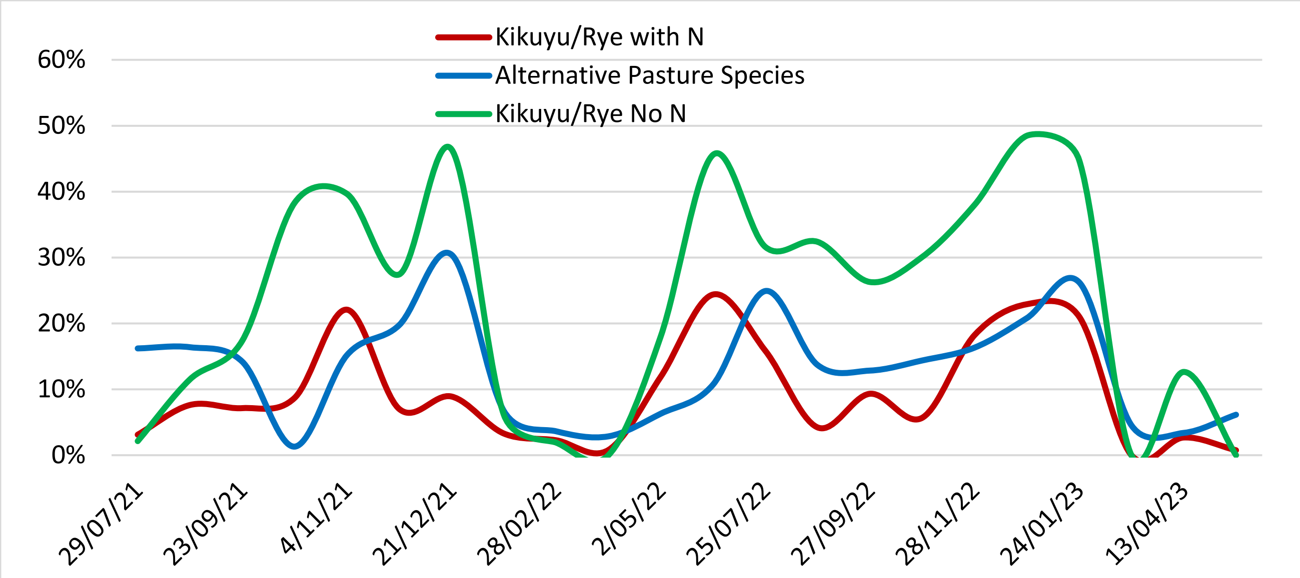


Pasture Composition

Pasture samples were collected monthly from the next three paddocks to be grazed on each farm and analysed for feed quality and species presence. Figure 3 shows the presence of clover in the pre-graze pasture samples collected through the two seasons. This was entirely white clover on the Current and Low Emissions Farms, with some red clover present in the Alternative Pastures Farm.

The removal of nitrogen application on the Low Emissions Farm showed a rapid increase in clover presence through at the start of the trial.

Figure 3. *Clover presence in pasture samples (% clover).*



Calculated Clover Nitrogen Fixation

As shown above, the Low Emissions Farm has had significantly higher clover presence through most of the study to date. Based on these assessments we estimated the amount of clover growth on each of the farms during the 2022 calendar year (see table 1). This then allows an estimate of nitrogen fixation, based on published studies (Ledgard et al, Plant and Soil 229: 177-187, 2001).

Based on these estimates, the additional clover presence may provide a significant contribution of nitrogen into the farm system, somewhat compensating for the lack of nitrogen application. Some of this clover fixed nitrogen would later become available to grasses, however it is likely that a significant proportion is lost before becoming available to other plants.

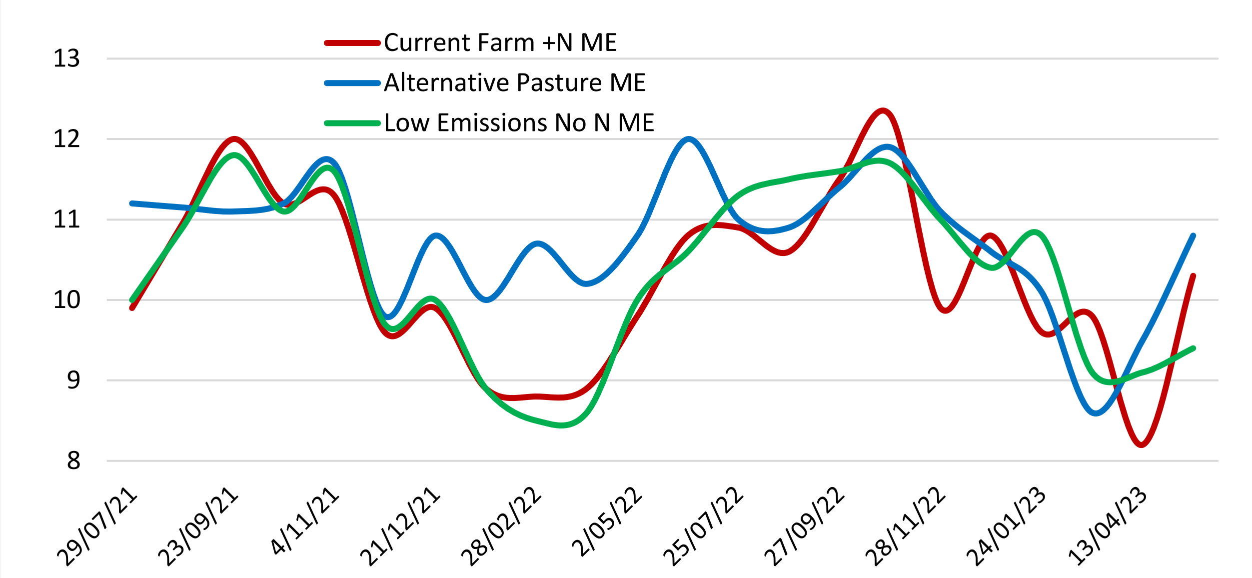
Table 1. *Nitrogen applied, estimated white clover growth and nitrogen fixation for the 2022 calendar year.*

Farm	Nitrogen Applied kg/ha	Clover Growth kg DM/ha	Estimated Nitrogen Fixation kg/ha
Current Farm	189	1,824	90
Alternative Pastures Farm	190	2,105	104
Low Emissions Farm	0	3,731	228

Pasture Quality

Pasture ME as shown in Figure 4 indicates that the fescue/cocksfoot pastures had significantly higher feed quality through the 21/22 summer period, primarily due to the strong chicory presence during the dry conditions. Good clover growth during the second summer on the Low Emissions and Alt Pastures farms contributed to a quality advantage also.

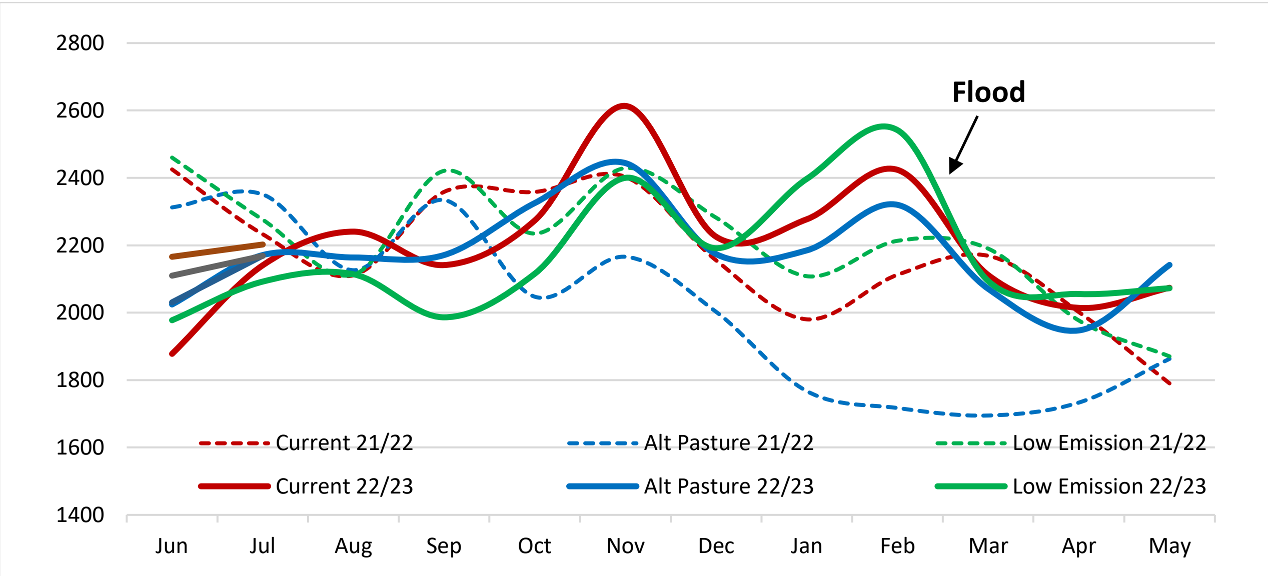
Figure 4. Pasture metabolisable energy content (MJ ME/kg DM) over two seasons.



Pasture Covers

Figure 5 shows the pasture cover on the farms through the season. Good summer rainfall supported high pasture covers throughout the second summer, until the flood hit in mid February 2023.

***Figure 5.** Average pasture cover on farms – monthly average.*



Supplement Fed & Pasture Eaten

Table 2 shows the supplement fed during the 2022/23 season, the cost of those supplements, and the calculated feed eaten for each of the farms.

Due to greater pasture feed deficit during winter/early spring, the Current Farm purchased more supplement than the Alternative Pastures Farm. The Current Farm also made less silage, indicating that it grew significantly less pasture during winter/spring than the Alternative Pastures Farm.

The slow pasture growth rates and covers during winter resulted in the Low Emissions Farm purchasing 163 kg DM/cow of supplement, significantly more than the previous season. However, very little supplement was fed from early spring on resulting in the Low Emissions Farm ended the season with 298 kg DM/cow more silage on hand than it started.

The calculated pasture eaten data indicates that the Alternative Pastures Farm had the highest pasture eaten while the Low Emissions farm cows consumed 2 t DM/ha less pasture than the Current farm.

Table 2. *Supplement made and purchased during 2022/23 season – modelled post-flood.*

Farm	Supplement	Kg DM/cow fed	Cost of Supplement (incl Freight)	Total Cost of Supplement c/kg DM	Calculated Pasture Eaten t/ha
Current Farm	Home-made Silage PKE Purchased Silage **Total**	285 503 212 **999**	$62/bale $463/t $108/bale	22.2 51.4 43.1	13.1
Alternative Pastures Farm	Home-made Silage PKE Purchased Silage **Total**	346 386 213 **945**	$62/bale $463/t $108/b	22.2 51.4 43.1	14.4
Low Emissions Farm	Home-made Silage PKE **Total**	293 163 **455**	$62/bale $463/t	22.2 51.4	11.1

Milk Production

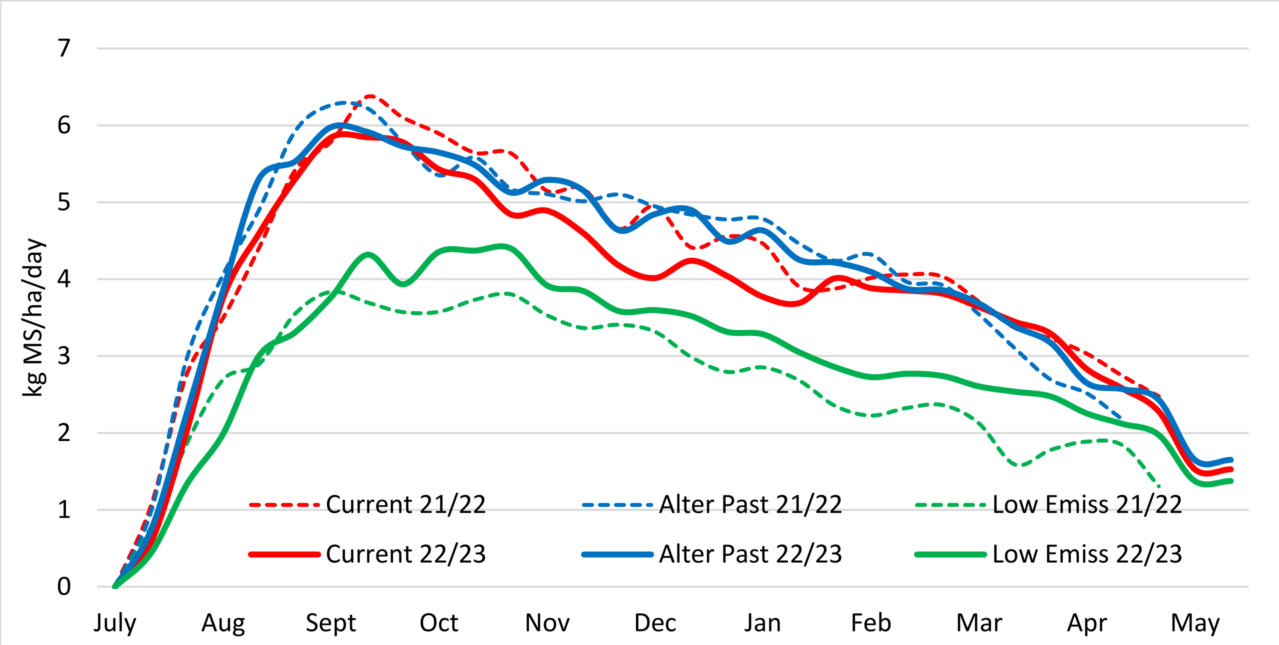
Milk production is shown in table 3 and figure 6. The Alternative Pastures Farm had higher milk production than the Current Farm during the 2022/23 season. This is in contrast to the previous season where the Current Farm had the highest production. Climatic differences between the two years are responsible for this difference. The kikuyu based pastures on the Current Farm supported milk production through a dry summer/autumn in 2022, while the Alternative Pastures Farm cows were dried off early. A wet summer/autumn during 2023 allowed the Alternative Pastures Farm to continue milking right through, with higher production than the Current Farm through summer/autumn, likely due to higher clover/herb presence.

Milk production on the Low Emissions Farm was significantly higher during 2022/23 than it was the previous season. This is attributed to better management of early spring grazing rotation length to ensure pasture quality was maintained.

Table 3. *2021/22 & 2022/23 Season Milk Production (kg MS/ha & kg MS/cow), modelled post-flood.*

	2021/22 Season		2022/23 Season (Modelled)	
Farm	**Kg MS/ha**	**Kg MS/cow**	**Kg MS/ha**	**Kg MS/cow**
Current Farm	1,284	409	1,204	392
Alternative Pastures Farm	1,213	397	1,269	406
Low Emissions Farm	794	370	910	399

Figure 6. *Milk Production – kg MS/ha/day (10 day average), modelled post-flood.*



Mating Results

Table 4 shows the mating results for the two seasons. Overall, there were no significant differences between farms.

Table 4. *2021/22 & 2022/23 Season 6 week in-calf and empty rates.*

Farm	2021/22 Season 6 Week In-calf Rate	Empty Rate	2022/23 Season 6 Week In-calf Rate	Empty Rate
Current Farm	79%	11%	81%	10%
Alternative Pastures Farm	74%	9%	82%	11%
Low Emissions Farm	75%	3%	82%	12%

Greenhouse Gas Emissions

Greenhouse gas (GHG) emissions were calculated using the Overseer model and are shown in table 5. Overall emissions were highest on the Alternative Pastures Farm, due to higher feed eaten.

The Low Emissions farm showed significant reductions in GHG emissions compared to the Current farm, especially in the CO_2 profile of the farm inputs which on the other farms were mainly made up by nitrogen fertiliser and supplements. Surprisingly, the calculated CO_2 emissions/kg product was also lower on the Low Emissions farm despite it having a 25% reduction in milk production compared to the Current farm. This improvement in efficiency appears to be largely due to the lower farm input emissions (nitrogen fertiliser and supplements).

Table 5. *2022/23 Season Calculated GHG Emissions – tonne CO_2 equivalent/ha and kg CO_2/kg milk solids using Overseer model.*

Farm	Methane (CO_2 equivalent) tonne/ha	Nitrous Oxide (CO_2 equivalent) tonne/ha	Input CO_2 tonne/ha	kg CO_2/kg MS
Current Farm	9.2	2.2	1.8	10.3
Alternative Pastures Farm	10.0	2.4	1.7	10.4
Low Emissions Farm Compared to Current farm	6.6 29% reduction	1.2 44% reduction	0.5 70% reduction	9.2 16% reduction

Financial Analysis

The financial results for the three farms are shown in Table 6. These are preliminary results as not all expenses and income items are finalised for the season. Expenses are based on actual farm expenses with some adjustments for labour and administration to compensate for extraordinary expenses involved in running the research trial. With the event of the flood, some of the actual expenses have been altered to reflect the predicted farm production and activities based on if the flood had not occurred. Records of additional labour and tractor time for each farm have been used to adjust the vehicle, R&M, and depreciation expenses.

Farm working expenses per kg milk solids (FWE) were highest on the Current Farm, at $6.77, due to lower milk production (than the Alternative Pastures Farm) and higher purchased supplement. FWE were lowest on the Low Emissions Farm. In the previous season FWE/kg MS were similar across all farms at around $5.70/kg MS.

Assuming a $8.20/kg MS milk price for the 2022/23 season, farm operating profit per ha was highest on the Alternative Pastures Farm at $2,707. The other two farms were significantly lower, with the Current Farm having the lowest operating profit. This is quite different than the previous season where the Low Emissions Farm operating profit was significantly lower than both other farms. Higher milk production on the Low Emissions Farm this season is a contributor to this improved relative farm profit, along with increased input costs (e.g. fuel and nitrogen) impacting the higher input farms to a greater degree than the low input Low Emissions Farm.

Alternative milk prices are overlayed in this analysis and show that the Low Emissions Farm would have the highest operating profit if milk price was $6.00/kg MS, (all other things being equal).

Table 6. *2022/23 Preliminary Financial Results - income, expenses, and operating profit for the three farms ($/ha).*

Financial Summary 2022/23 Season	Current Farm	Alternative Pastures Farm	Low Emissions Farm
Income	**$/ha**	**$/ha**	**$/ha**
Income from milk ($8.20/kg MS)	$9,846	$10,301	$7,515
Dividends and other income	$60	$131	$255
Income from stock sales	$717	$725	$539
Total Income/ha	**$10,623**	**$11,157**	**$8,309**
Expenses			
Wages	$2,118	$2,067	$1,436
Animal Health	$495	$499	$383
Breeding Expenses	$294	$296	$224
Shed expenses	$291	$292	$236
Electricity	$285	$287	$224
Grazing	$662	$669	$497
Calf rearing	$90	$91	$68
Silage Making	$200	$292	$333
PKE	$788	$567	$190
Purchased Silage	$283	$291	$15
General Fert	$97	$96	$97
Nitrogen Fert	$457	$472	$0
Regrassing	$376	$328	$377
Weed and Pest	$100	$99	$100
Vehicle Expenses	$402	$375	$316
R&M Buildings	$14	$14	$12
R&M General	$690	$689	$601
R&M Effluent	$15	$14	$9
Administration	$222	$220	$211
Insurance	$75	$75	$69
Rates	$158	$156	$158
Depreciation	$612	$573	$333
Total Operating Expenses/ha	**$8,711**	**$8,449**	**$6,027**
Farm Working Expenses $/kg MS	**$6.77**	**$6.28**	**$6.00**
Operating Profit (at $8.20/kg MS)	**$1,912**	**$2,707**	**$2,282**
2022/23 Operating Profit with Alternative Milk Prices			
Operating Profit at $6.00/kg MS	**-$730**	**-$128**	**$70**
Operating Profit at $10.00/kg MS	**$4,073**	**$4,896**	**$3,736**
2021/22 - Previous Seasons Operating Profit			
2021/22 Operating Profit (at $9.30/kg MS)	**$4,952**	**$4,699**	**$2,974**

Discussion & Learnings

The two seasons that this study has run so far have been climatically quite different (dry summer vs wet summer) and have resulted in quite different results. It appears the wetter summer of 2023 benefited the Alternative Pastures Farm with the tall fescue and/or cocksfoot pastures, while these pastures during the previous drier 2022 summer/autumn showed low growth rates resulting in cows drying off early. Kikuyu growth on the Current Farm supported the kikuyu-based farm during that dry season. More seasons are required to clarify if the investment in alternative pastures will benefit farm profitability in the long term. It must be noted that the kikuyu based pastures are intensively managed and under-sown with Italian ryegrass annually, so the alternative pastures species are being compared with a highly managed and productive system.

The removal of nitrogen fertiliser within the Low Emissions Farm has resulted in a consistent reduction in pasture growth during winter and spring compared with the Current Farm. Overall, the Current Farm grew 2.6 t DM/ha more than the Low Emissions Farm during the 2022/23 season, indicating a nitrogen response of 16 kg N applied. This is considered a good nitrogen response and is despite the significantly higher clover presence on the Low Emissions Farm and an estimated additional 138 kg N/ha fixed by that clover. No doubt the high clover growth on the Low Emissions Farm somewhat compensated for the lack of applied nitrogen, however the pasture growth shortfall is still significant.

A reduction in stocking rate on farms can often be associated with a drop in per cow production due to poorer pasture management, especially on kikuyu based pastures. This was seen in the 2021/22 season where pasture quality deteriorated during early spring on the Low Emissions Farm resulting in lower per cow production. In the 2022/23 season pastures were better managed with improved pasture utilisation and all surplus pasture during late spring harvested as silage. These two seasons have illustrating the importance of maintaining high pasture utilisation where lower stocking rates are employed.

This project expected to reduce methane emissions 25% and nitrous oxide emissions by 50% on the Low Emissions Farm compared to the Current Farm. The actual (modelled) reduction in the 2022/23 season was 29% and 44% respectively, which is somewhat in line with the reduction in stocking rate and milk production. The reduction in emissions per kg milk solids (16%) is more impressive and indicates the potential for lower input systems like the Low Emissions Farm to be more efficient from a green house gas emissions perspective.

In the 2022/23 season the Low Emissions Farm showed a slightly higher operating profit than the Current Farm, thus there was no cost to achieve these emissions targets. This was very different than the previous season where the profit advantage to the Current farm was $1,974/ha more profitable than the Low Emissions Farm. The variation in farm profit between these two seasons has illustrated the importance of comparing farm systems under a number of different climatic and economic environments.

Acknowledgements

Thanks to NARF staff for making this project happen on the ground. Special thanks to NDDT trustees and NARF committee members for their support and commitment in proposing, overseeing, and managing this project.

For more information go to nddt.nz or to receive fortnightly email updates, contact info@nddt.nz.

Contacts

Terence Brocx – NDDT Chair, roundtuit@slingshot.co.nz
Kim Robinson – NDDT Coordinator, kim.robinson@agfirst.co.nz
Chris Boom – NDDT Science Manager, chris.boom@agfirst.co.nz

AGFIRST