Leading Innovation for
Southern farmers' propserity

Southern Dairy Hub
March Field Day 2024

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Contents


Farm Map
Farmlet
Std Infrastructure
LI Baleage
Std FB
LI FB
Farm
Support
0
200
400m

Visitor Health and Safety Requirements

General Rules

- Children on farm – must be under constant adult supervision and only with express permission of manager
- Reporting – please notify manager immediately any accidents or near miss events/hazards
- Drive to the conditions – maximum speed of 30km/hr 

- Vehicles – no one to operate farm vehicles without manager's permission
- Water ponds/troughs – keep a close eye on children around water sources – do not drink from farm taps, troughs, water ways
- In an emergency – please report back to farm manager at Assembly point in front of cowshed
- Fire extinguishers – found in farm houses, dairy shed, vehicles, and woolshed
- No smoking in cowshed, buildings, or vehicles

Biosecurity Requirements for Southern Dairy Hub (SDH)

All visitors must comply with Biosecurity Requirements when visiting SDH

- All footwear must be disinfected with materials supplied, upon arrival at and departure from the SDH farm site.
- All visitors are expected to wear clean protective clothing, including wet weather gear if necessary, when on the farm(s).
- No farm visits will be allowed, from anyone within five days of their arrival in New Zealand from overseas.
- SDH retains the right at any time to refuse access to any person or persons deemed not to be complying with these requirements.

2023-24 Season to date update

Pasture supply

Pasture growth through summer has been strong. Moisture and soil temperatures have not been limiting factors, with growth rates through January and February being 11 to 14 kg/DM/ha/d higher than the 5-year average (Figure 1, Table 1). This has led to covers being higher than the same period last year (Figure 2), with most of the cows' diet able to come from pasture. The standard treatments have grown 1329 kg/DM/ha pasture more than our 5-year average, 1890 kg/DM/ha more than last year, while the lower impact treatments are 1492 kg/DM/ha ahead of the 5-year average and 1355 kg/DM/ha ahead of last year. (Table 1)

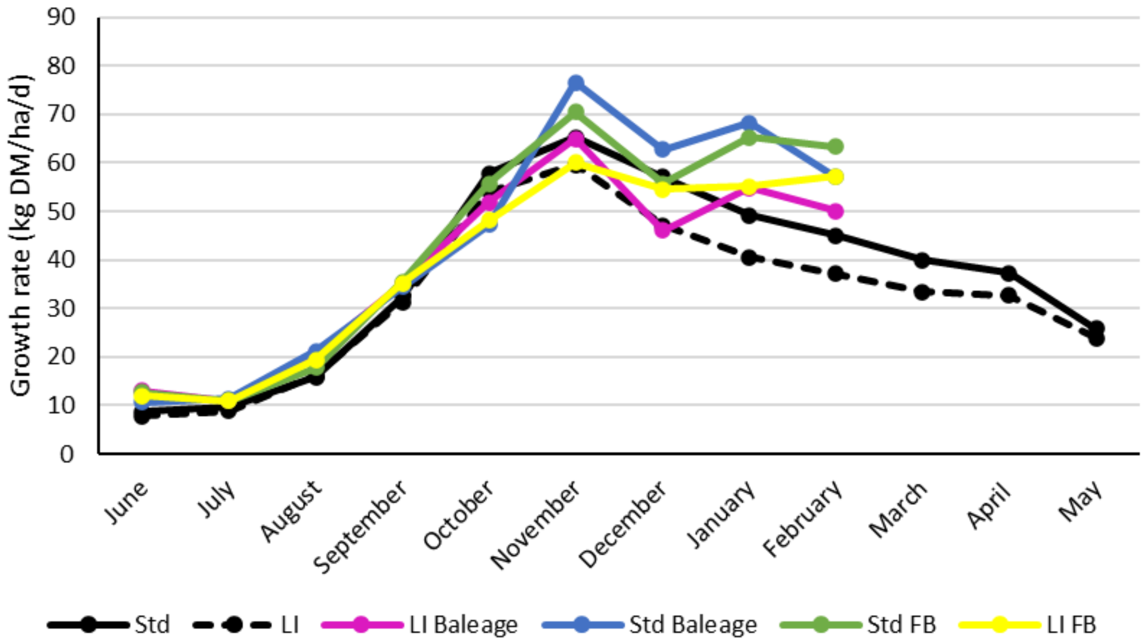


Figure 1: Average monthly pasture growth rate for 2023-24 season compared with the 5-year average

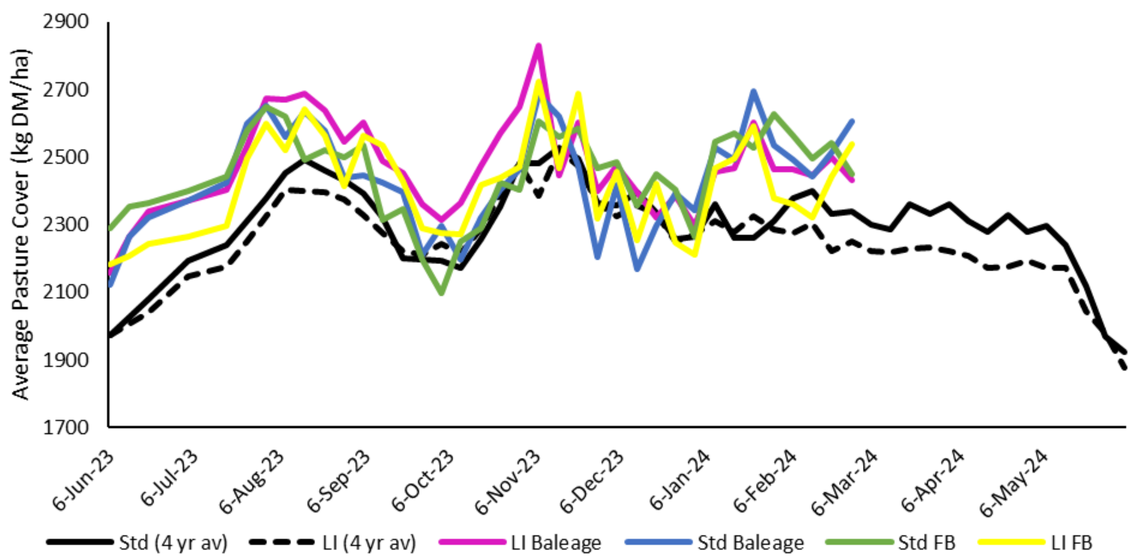


Figure 2: Average weekly pasture cover (kg DM/ha) compared with the 2022-23 season

Table 1: Average monthly growth rates compared with the previous 4 seasons

SDH monthly growth rate summary													
		180-190 kg N						50 kg N					
	Days	Mean	2019-20	2020-21	2021-22	2022-23	2023-24	Mean	2019-20	2020-21	2021-22	2022-23	2023-24
June	30	9	6	12	10	7	12	9	7	9	11	5	13
July	31	10	12	7	12	10	11	9	10	8	9	9	11
August	31	17	13	19	19	13	20	17	14	19	18	15	20
September	30	30	29	31	31	39	35	29	26	32	30	37	35
October	31	57	56	50	65	61	51	53	50	50	58	59	50
November	30	65	69	67	59	66	74	59	62	61	53	63	63
December	31	53	53	57	50	69	59	43	48	44	37	60	50
January	31	55	50	73	43	31	67	44	44	52	37	30	55
February	29	49	51	57	41	31	60	40	42	41	36	29	54
March	31	39	42	51	23	43		32	32	42	22	39	
April	30	33	42	33	24	51		28	33	32	20	46	
May	31	24	23	24	25	31		22	20	21	24	30	
STD (kg DM/ha)		10470	10207	11219	9983	9909	11799	9146	9169	9519	8749	9282	10637
Total (kg DM/ha)		**13458**	**13530**	**14592**	**12264**	**13744**		**11695**	**11817**	**12460**	**10816**	**12793**	
Diff to 4 yr Average							**1329**						**1492**
Diff to 2022-23							1890						1355

Pasture quality

Pasture growth being consistently higher than demand has meant surplus management has been a priority to maintain quality, with minimal in shed feeding, 1168 bales of baleage made, and significant topping to maintain the correct pre-graze covers and residuals (Table 2). Some issues with this and different species means the current range in quality is between 10 and 12 MJME/kg DM in grazed pastures. Pasture quality between the Std and LI treatments appears to be similar (Table 3).

Table 2: Conservation and topping summary season to date.

Figure 3: Soil temperature compared with the 2022-23 season

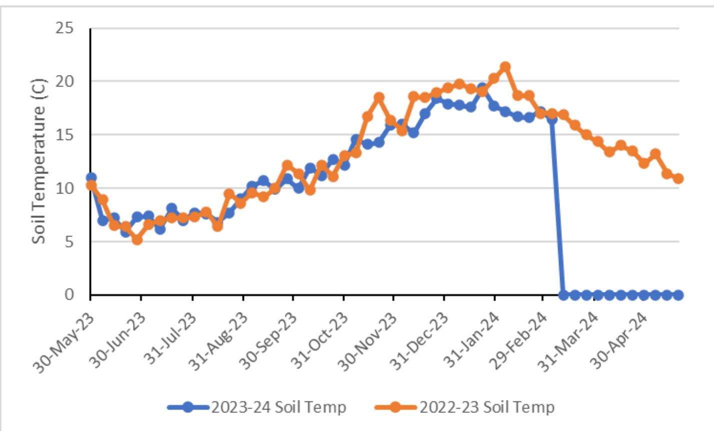
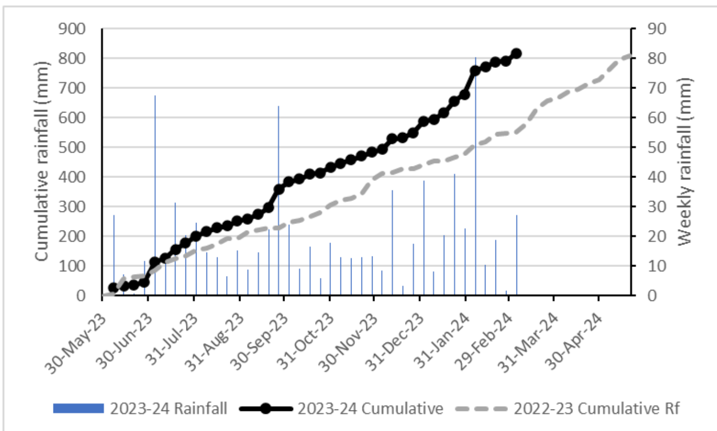


Figure 4: Rainfall compared with the 2022-23 season



	Grazeable Area	Conserved STD (%)	Topped STD (%)	Total % of farm mown	Bales Made
Std Baleage	52.2	54.6	93.9	148	225
LI Baleage	93.6	70.4	86.5	157	404
Std FB	75.3	55.5	50.2	106	311
LI FB	55	57.8	110.5	168	212

Table 3: Pasture quality summary from monitor paddocks

		DM (%)	ME (MJ/kg DM)	Crude protein (% DM)	NDF (% DM)	ADF (% DM)	Ash (%)	NSC (% DM)	Soluble Sugars (% DM)
Standard	1st round	17.6	12.2	20.0	39.8	20.6	9.9	26.9	11.4
180 kg N/ha	2nd round	18.3	12.3	23.0	39.2	20.9	10.7	23.7	10.7
	3rd round	15.8	12.0	23.4	43.3	21.7	10.6	18.7	8.1
	4th round	18.0	11.5	22.3	47.6	24.3	10.6	15.7	4.0
	5th round	19.8	11.3	22.8	48.3	24.8	10.9	14.2	4.0
	6th round	18.7	11.7	21.9	45.1	22.7	9.7	19.6	7.1
	7th round	19.0	11.4	21.5	46.6	23.5	9.8	18.3	7.1
Range		8.7-23.3	10.6-12.9	13.2-29.5	34.6-55.9	18.8-29.0	8.6-13.5	4.7-34.5	0.8-16.2
Lower Impact	1st round	17.1	12.2	20.8	39.3	20.0	10.4	25.8	11.0
50 kg N/ha	2nd round	16.4	12.1	22.8	39.3	20.8	11.3	23.5	12.4
	3rd round	16.1	12.1	20.6	40.2	21.1	10.5	25.5	11.4
	4th round	17.9	11.4	22.5	47.0	24.3	11.3	15.5	4.7
	5th round	19.4	11.3	20.7	46.9	24.7	11.2	17.5	5.0
	6th round	19.2	11.2	18.2	44.5	23.4	9.4	24.7	7.5
	7th round	16.8	10.9	22.6	48.1	25.6	11.2	14.6	3.8
Range		11.8-23.7	10.4-12.9	16.7-25.7	32.8-52.9	17.8-28.8	8.8-14.9	5.9-34.8	1.3-22.1

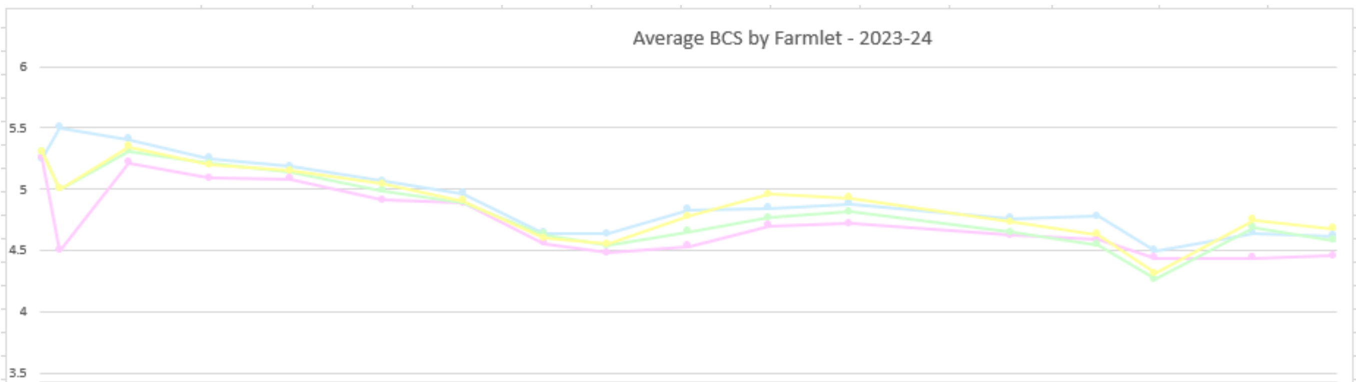
Reproduction

Repro results are average 78% six week in calf rate, (75%-83% across the farmlets), now the final scan results are in dry off plans are being determined. Not in calf rates are a disappointment given such a good six week in calf rate and the data behind this result is being looked at.

Table 4: Reproduction summary

	6 Week in calf rate	Not in Calf Rate
Standard Baleage	76%	16%
Lower Impact Baleage	75%	12%
Standard Fodder beet	79%	12%
Lower impact Fodder beet	83%	9%
Average	78%	

Average herd body condition score is looking OK for this time of year, although there is a range in condition across all the herds. The focus is now on identifying early calving light conditioned cows and developing a management plan to ensure they achieve their dry off and calving BCS targets.



	24-Jul-23	27-Jul-23	8-Aug-23	22-Aug-23	5-Sep-23	21-Sep-23	5-Oct-23	19-Oct-23	30-Oct-23	13-Nov-23	27-Nov-23	11-Dec-23	8-Jan-24	23-Jan-24	2-Feb-24	19-Feb-24	4-Mar-24
	5.2	5.5	5.4	5.3	5.2	5.1	5.0	4.6	4.6	4.8	4.8	4.9	4.8	4.8	4.5	4.6	4.6
	5.3	4.5	5.2	5.1	5.1	4.9	4.9	4.6	4.5	4.5	4.7	4.7	4.6	4.6	4.4	4.4	4.5
	5.3	5.0	5.3	5.2	5.1	5.0	4.9	4.6	4.5	4.7	4.8	4.8	4.6	4.5	4.3	4.7	4.6
	5.3	5.0	5.3	5.2	5.1	5.0	4.9	4.6	4.6	4.8	5.0	4.9	4.7	4.6	4.3	4.8	4.7

Figure 5: Average body condition score by farmlet

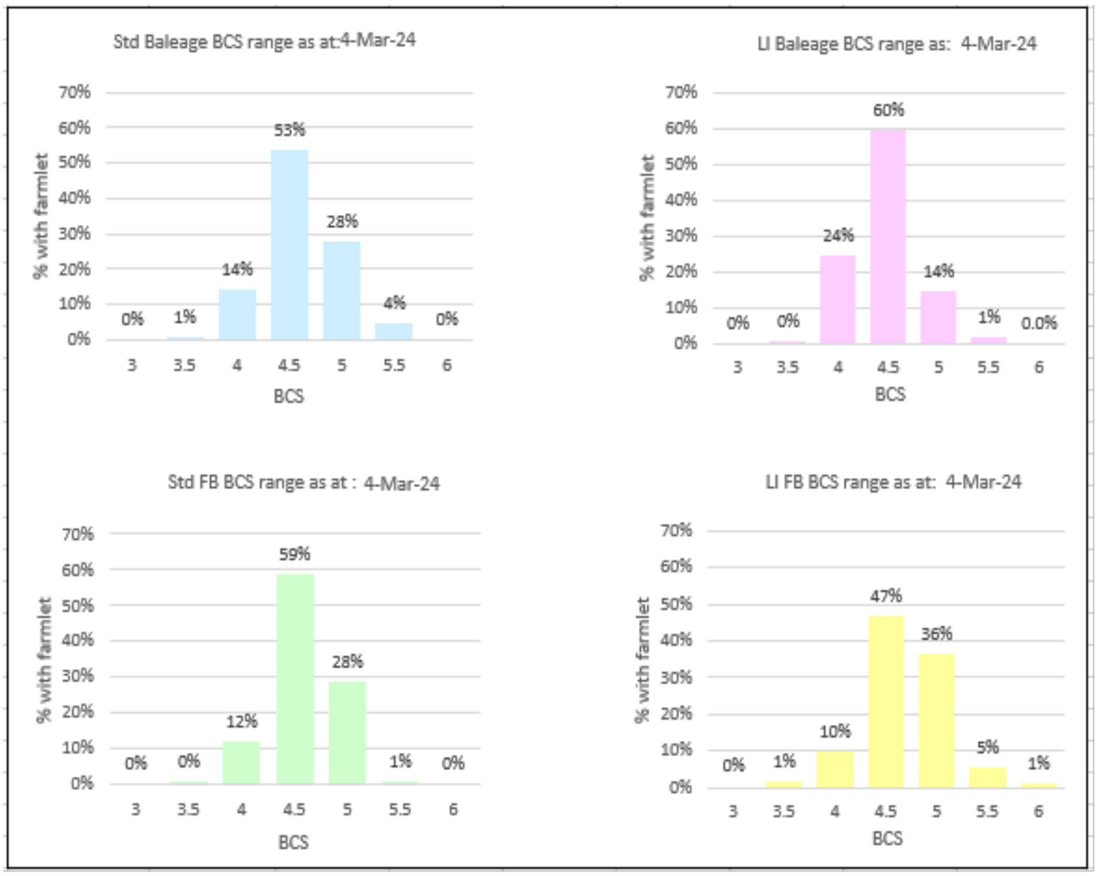


Figure 6

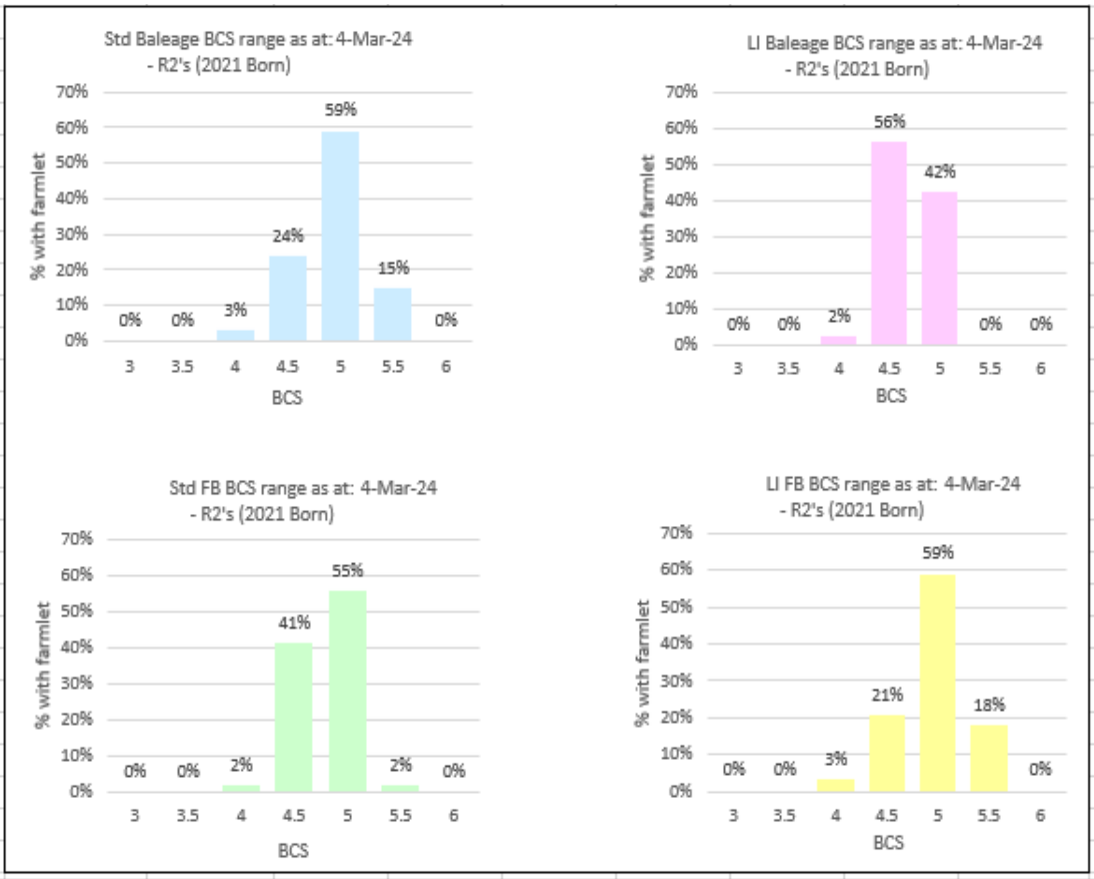


Figure 7

Milk production

Milk production is currently ahead of last season by 6% (8,000 milk solids), and more cows will be able to be milked for longer this autumn (weather permitting) due to more harvested surplus baleage being available to feed.

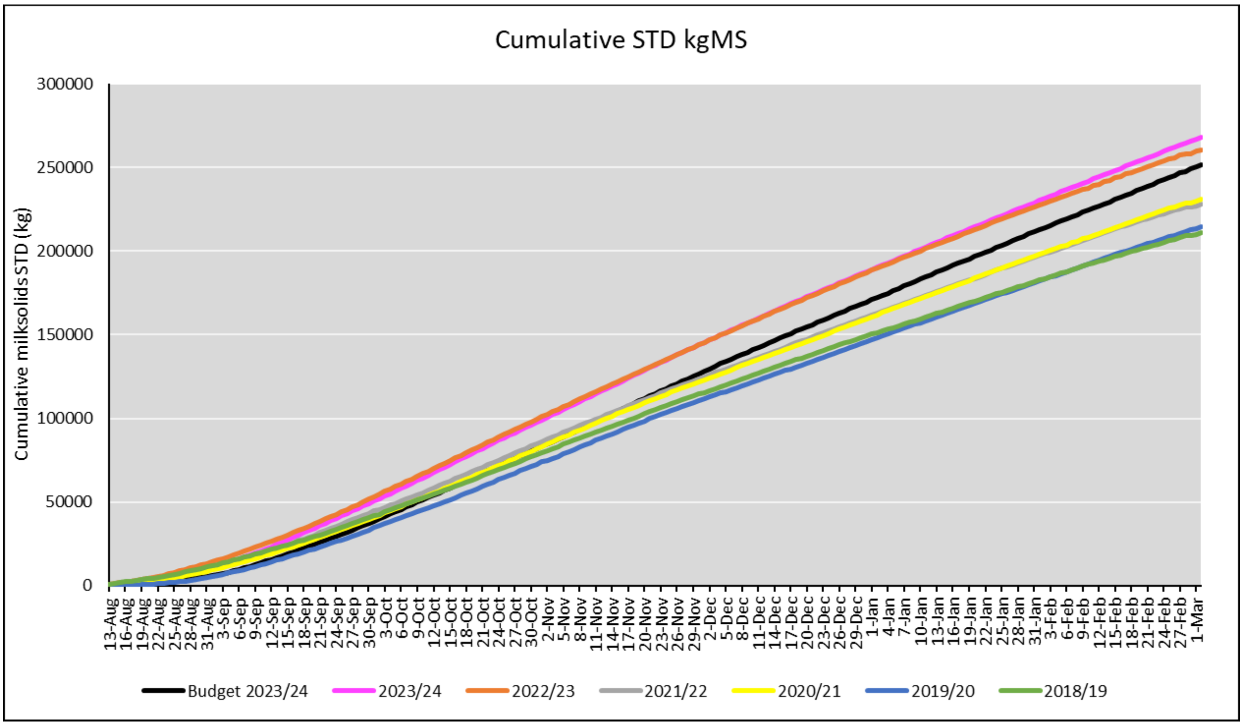


Figure 8: Cumulative milk solids production season to date

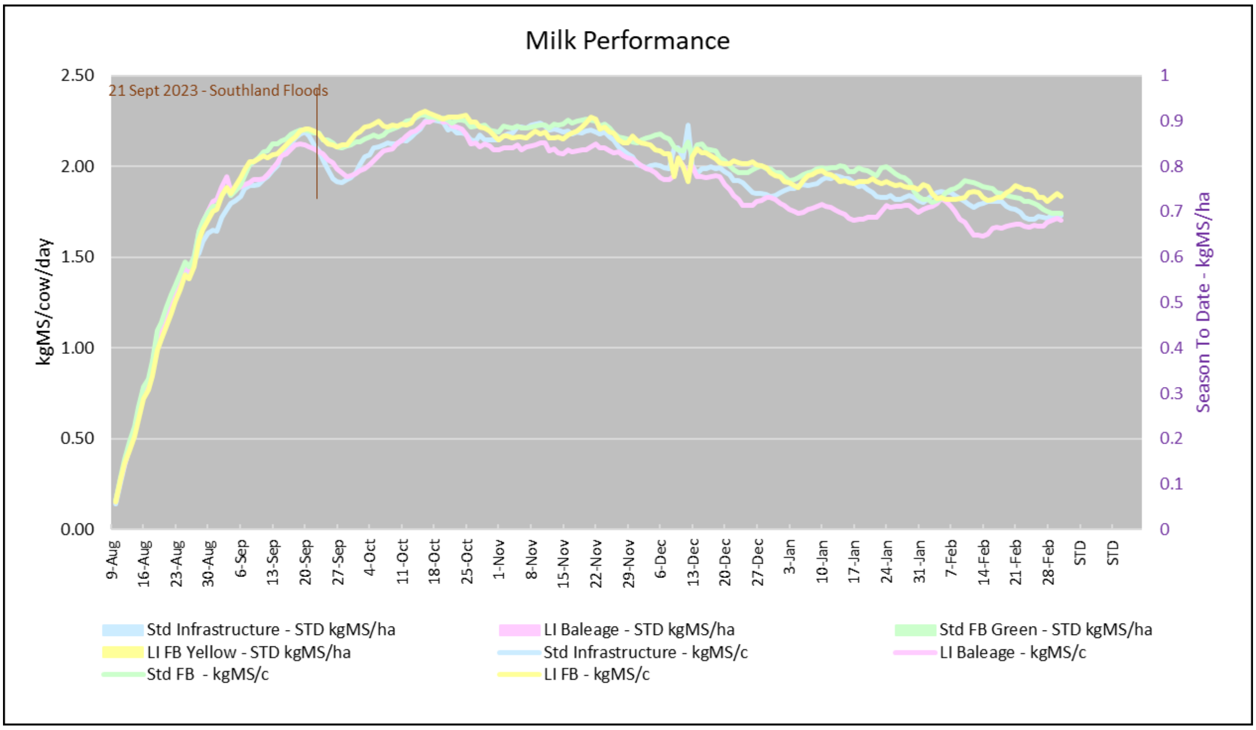


Figure 9: Milk performance

Plantain: a cost-effective N-mitigation tool

The Sustainable Food and Fibre Futures Plantain Potency and Practice Programme is a seven-year (2021-2028) Aotearoa New Zealand-wide collaborative research and development initiative. The aim is to substantially reduce nitrogen (N) lost to fresh water and greenhouse gases from the pasture-based food exporting sectors by using plantain (Ecotain®).

The programme now has compelling evidence of the efficacy of plantain (cv. Agritonic, marketed as Ecotain) for reducing nitrogen leaching at farm scale in two environments (Lincoln and Massey Universities). Pasture and animal production at both sites have been maintained at similar levels to perennial ryegrass/clover systems.

The following key messages represent the state of knowledge relating to plantain. The Plantain Potency and Practice Team is continuing to add to these messages as the programme progresses.

Production

When grown in a mixed sward with ryegrass and clover at the Massey and Lincoln Farmlet trials, plantain has not negatively affected milk production, pasture growth or quality. Plantain mixed swards have higher production in the summer/autumn period in summer dry environments. At the local field trial site in Edendale, plantain/ryegrass swards have outperformed perennial ryegrass (Figure 10). Note there is no clover in the sward at this site.

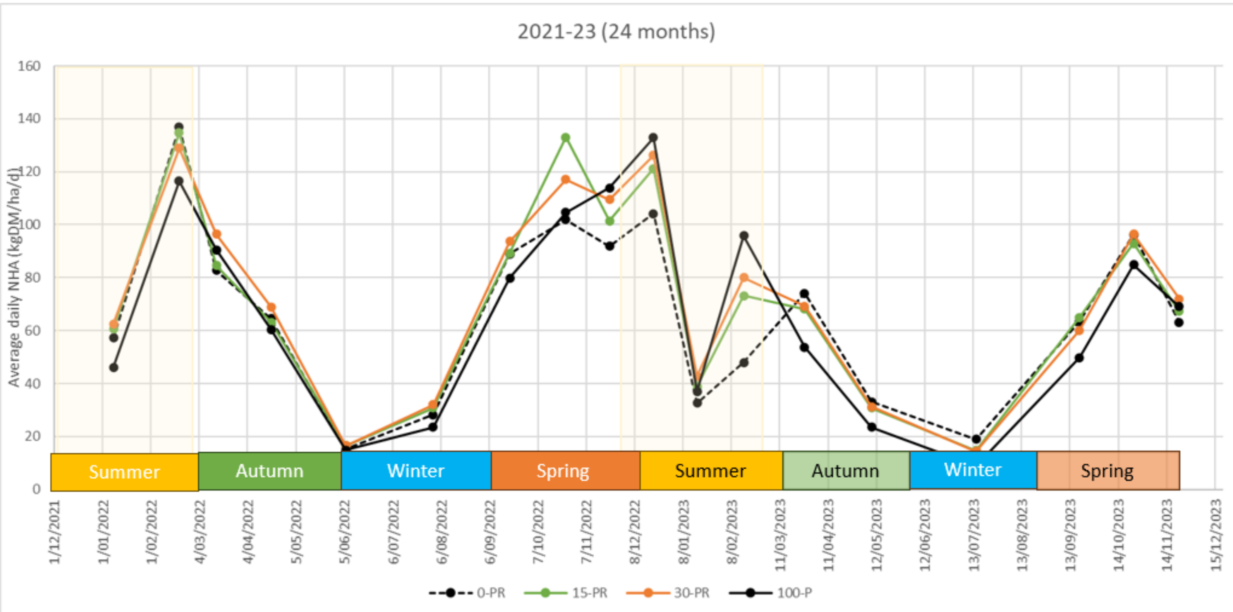
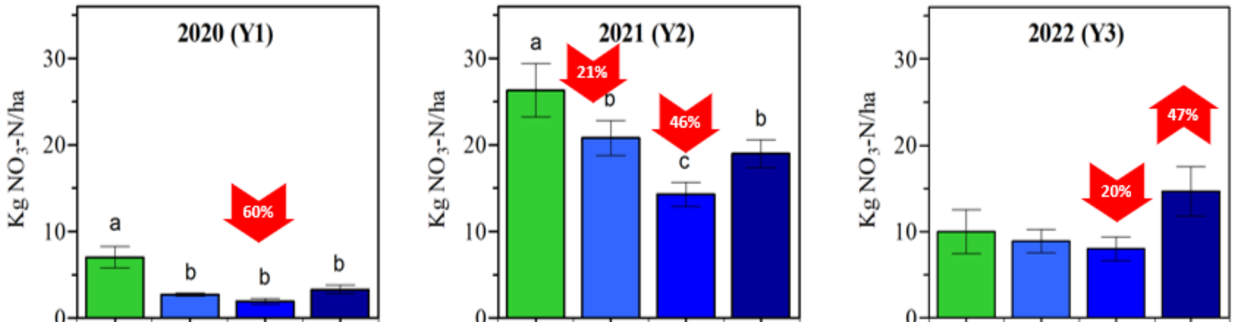


Figure 10. Pasture growth with increasing proportion (0%, 15%, 30% and 100%) of plantain in the sward at Edendale.

Efficacy for Reducing Nitrate Leaching

On heavy soils at Massey University, nitrate leaching reductions were 20-60% from pastures with 20-50% plantain making up 15-30% of the diet (3 years data). The amount of leaching varied between years. Where plantain proportion decreased in the third year, reductions in N leaching were smaller. In one treatment with very high clover (34%), leaching was higher. Previous work indicates higher leaching at clover levels above 20%.



2020 (Y1)	RGWC	A	B	C
%PL_s	---	30	42	50
%PL_d	---	22	29	35
%WC	10	6	8	7
%RG	70	53	43	36

2021 (Y2)	RGWC	A	B	C
%PL_s	---	32	47	45
%PL_d	---	21	31	31
%WC	18	20	20	19
%RG	67	40	28	26

2022 (Y3)	RGWC	A	B	C
%PL_s	---	18	22	44
%PL_d	---	12	15	30
%WC	13	13	13	34
%RG	79	65	58	14

Figure 11. Nitrate leaching at Massey University Farmlet Trial.
%PLs = plantain in the sward; %PLd = plantain in the diet; %WC = white clover; %RG = ryegrass.

At Lincoln under irrigation, pastures containing 15-30% Ecotain® plantain are showing 20% reduction in total nitrogen leaching (two years data) compared with perennial ryegrass/clover (Figure 12).

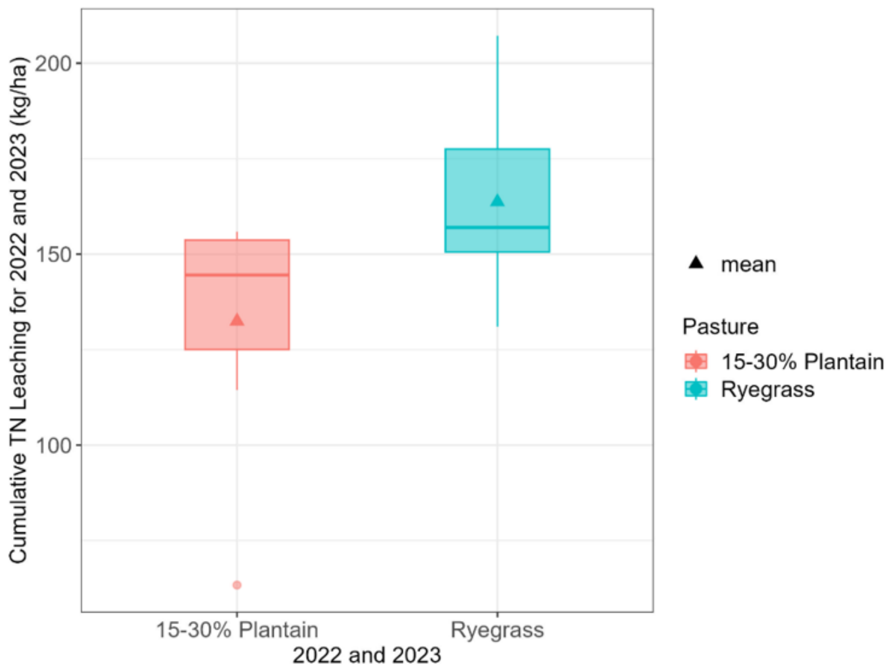


Figure 12. Total nitrogen leaching plantain/ryegrass/clover vs. ryegrass/clover at Lincoln 2022 and 2023

Efficacy for Reducing Nitrous Oxide Emissions

Evidence is growing for the effect of Ecotain® plantain on reducing nitrous oxide emissions. Research from AgResearch and the NZ Agricultural and Greenhouse Gas Research Centre has shown that emissions from the urine patch can be decreased proportionally with the amount of plantain in the sward. In a recent trial at Southern Dairy Hub during a dry autumn (2023), three pure sward plantain cultivars reduced nitrous oxide emissions from urine patches taken from cows grazing ryegrass/clover pastures by 39, 57 and 63%. In the same trial located in the Waikato during a wet autumn (2023), reductions were 12, 15 and 3%. The effect of plantain on nitrous oxide emissions appears to vary with soil and climate and more data are required to quantify and upscale the effect.

How Plantain Works

Ecotain plantain works to reduce nitrogen leaching from the urine patch in three ways as shown in Figure 13. 'Dilution' of the urine patch occurs due to the higher amount of water in the plantain feed compared to ryegrass. Animal urinate more frequently and each patch has less nitrogen. When an animal eats plantain, less nitrogen is 'partitioned' to urine and a greater amount is partitioned to dung and milk. This occurs due to the nutritional make-up of the feed (protein and carbohydrate fractions) compared to ryegrass. Plant secondary compounds found in the leaf of plantain may also influence these mechanisms and this is a focus of our animal trial work.

Ecotain® plantain has been shown to reduce nitrate leaching and nitrous oxide emissions in lysimeters even when the urine is from cows grazing a perennial ryegrass pasture. This soil effect may be due to a slowing of nitrification driven by plant secondary compounds in the root exudates. Several studies have also shown reduced drainage of water below the root zone from plantain pastures.

There is also evidence of nitrification inhibition driven by secondary metabolites found in urine from animals fed Ecotain® plantain.

Evidence is growing that the efficacy and magnitude of the soil effect is soil-type dependent. Confirming the efficacy and magnitude of these effects in different soils is a focus for the Plantain programme.

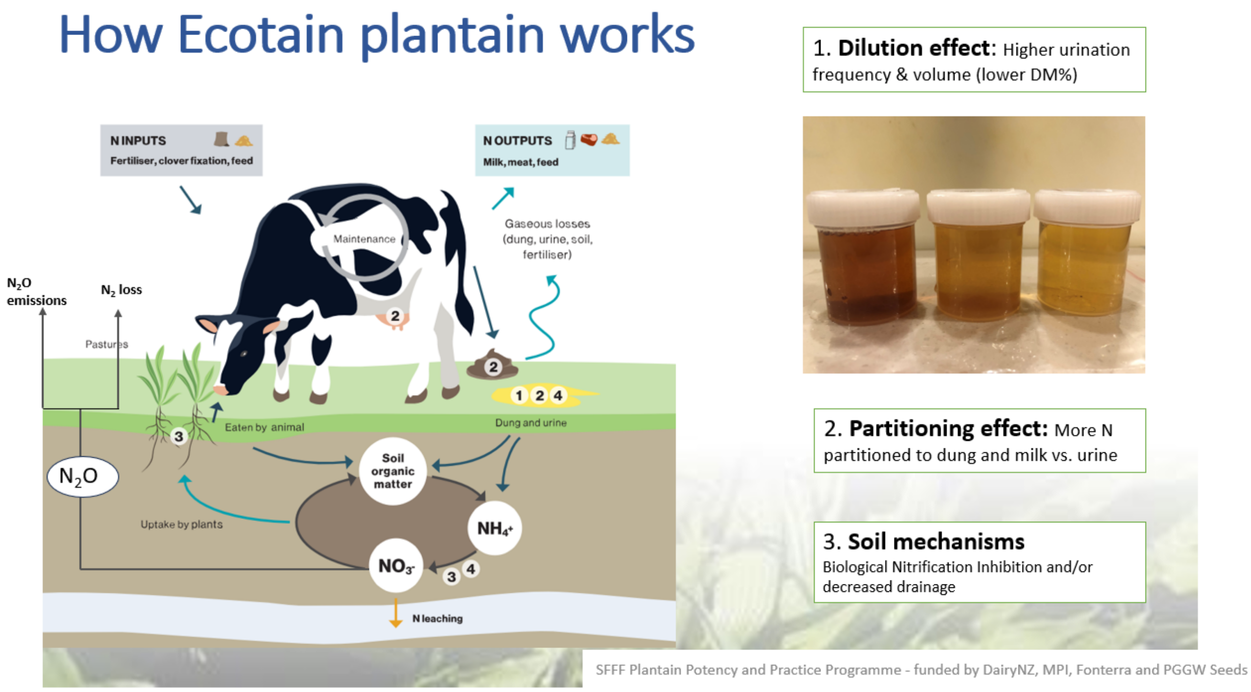


Figure 13. Nitrogen cycle showing the mechanisms of plantain for reducing nitrate leaching

Modelling Plantain in Overseer

Nitrate leaching reduction via the animal effects can be modelled in Overseer. On average, for partner farms, these effects have been modelled to achieve a 6% (range 3-8%) reduction in N leaching for every 10% of plantain in the pasture on average across the farm. Supplementary feeding, proportion of area in crop, soil type and rainfall affect the percent reduction.

Effectiveness of Different Plantain Cultivars

Evidence is growing that there is variation in both the animal and soil effects of different plantain cultivars. Currently Agritonic (marketed as Ecotain®) is the only cultivar with enough evidence to be promoted as effective. Research is ongoing to develop plant-based protocols for evaluating the effectiveness of other cultivars.

The Plantain programme has four plot trials comparing nine cultivars of plantain to ryegrass in four locations (including SDH). Early findings indicate that, based on the nutritional makeup of the forage, there could be a significant difference in nitrate leaching reduction from the most to least effective cultivars. A current animal experiment will provide more evidence of these differences and the key plant-based drivers. The trials are also indicating significant differences in seasonal production between cultivars.

Milk

Presence of secondary metabolites found in milk from plantain pastures are linked to health benefits (anticancer, antidiabetic, antioxidant, antimicrobial, antiviral) and risk to human health is classed as very low. Feeding Ecotain® plantain has little to no negative impact on milk yield, milk protein, lactose, solids, minerals or vitamins. Some level of milk fat depression has been observed in several studies where plantain intake was high. This is likely due to reduced dietary fibre in plantain, at times predisposing cows to subacute ruminal acidosis.

There is no negative effect of Ecotain® plantain on the processability of milk into products such as skim milk, cream, cheese, yoghurt or butter. Levels of the beneficial Omega 3 fatty acid are elevated in milk from plantain pastures, when plantain levels in the diet are high. Plantain feeding potentially also reduces free fatty acid content of milk, which is a desirable milk quality effect.

Animal Health

Based on data collected to date, plantain pastures appear to have lower facial eczema spores than perennial ryegrass pastures (data collection is ongoing).

Although we have not yet seen a consistent link between metabolic issues and plantain, farmers should be cautious with changing diet between pastures with and without plantain during calving due to differences in calcium, magnesium, potassium and sodium.

Animals may drink less water while grazing plantain and this may reduce intake of minerals or other medication supplied via inline water dispensers if these are used on farm.

Cows grazing pastures with a high proportion of plantain are at risk of bloat, particularly where white clover intake is high. Plantain appears to delay the onset of bloat; bloat on pastures containing plantain has been observed to occur later (2-5 hrs after fresh pasture allocation) than bloat seen on high clover pastures (typically 0.5-2 hrs after fresh allocation).

In the same soil, plantain takes up more copper than perennial ryegrass white clover pastures, and the copper in plantain may be more bioavailable to the animal, increasing liver copper stores. Farmers should monitor liver copper concentrations with their vet and adapt supplementation strategy if needed.

Observations suggest including plantain in pasture may reduce incidence of ryegrass staggers in pastures with wild-type endophyte, however this has not been confirmed in a controlled study.

Plantain Abundance and Persistence

Plantain is a short-lived perennial herb. Peak abundance in a mixed sward generally occurs at around 15 months after sowing, before levels decline each year over a period of up to four years. Abundance and persistence vary with soil, climate and companion species.

Plantain can be established as:

- A pure sward (12 kg/ha Ecotain with up to 5kg/ha clover) – oversow with grass as plantain thins
- A new mixed sward with grass and clover (3-4 kg/ha Ecotain with 8-20kg/ha clover)
- Under-sown into existing pastures (2-5 kg/ha) – caution with sowing too deep
- Broadcasted into existing pastures (2-5 kg/ha)

Plantain levels can be maintained by broadcasting or under-sowing into existing pastures. To get significant amounts of plantain across the farm, most farmers use a combination of new pastures and broadcasting across the whole farm.

Abundance and persistence of plantain is greater in more open swards and/or where the companion grass species is less competitive.

There are limited options for weed control in plantain pastures. Dictate (Bentazone) is now on label for controlling broadleaf weeds in plantain/grass/clover mixed swards. Farmers have had success with controlling broadleaf weeds on a 3-year cycle, and re-establishing plantain into mixed swards via broadcasting.

Plantain Management

In mixed swards, plantain should be managed on the same round length as ryegrass/clover. New swards should be grazed at the 6-leaf stage.

Overgrazing and treading damage will negatively affect persistence and should be avoided.

Low palatability can result from long rotations or high residuals, especially in autumn. Old leaves with low nutrient value are the primary reason for low palatability.

Seedhead production will reduce the life of the plant, so keeping the plant in a vegetative state where possible will extend its life.

Greenhouse gases and soil carbon

Beginning soil carbon research at the Southern Dairy Hub

Mike Dodd

Setting aside for a moment the potential for sequestering carbon in pastoral soils as a greenhouse gas mitigation opportunity (with an associated market), it is important to remember that soil organic matter plays other important roles in our pastoral soils. There are plenty of good reasons to increase soil organic matter, related to improving water holding capacity, greater nutrient retention and promoting the biological activity of soil. The last is essentially the foundation of the added value we get from the natural capital within pasture-based systems, before we augment it with industrial capital (fertiliser, lime, irrigation, drainage).

Having said that, there has been plenty of discussion about sequestration potential, the idea that our pastoral soils have additional capacity to store more carbon than they do at present. We should bear in mind that globally, long-term grassland soils usually have the highest carbon stocks of any production ecosystem, our New Zealand soils have some features that support high carbon concentrations (i.e. andisols), and our relatively high historical rates of nitrogen input (from legumes and fertiliser) are also conducive to carbon storage. Unfortunately, in New Zealand we have few studies on pasture management effects on soil carbon, with none showing sustained increases. This has led our soil scientists to doubt that there is great potential for increases, but rather focus on the downside risk of losses.

At the Southern Dairy Hub there is a programme of work, led by Cecile de Klein, looking at the greenhouse gas emissions implications of various existing and potential farm systems. It is important to consider changes in soil carbon alongside the modelling of methane and nitrous oxide, to ensure we have a complete picture. It has been said that “If you can’t measure it, you can’t manage it” and therefore we have commenced a study to measure soil carbon stocks at the research farm, at the beginning of the new farm systems research cycle. Primarily, this will give us a base data set to measure farm system effects over a four to five-year period, which is generally considered a minimum to be able to detect changes in soil carbon.

The first step in measuring soil carbon at a farm scale is a suitable soil map provided by a pedologist (1:5000 scale). This provides the basis for a balanced sampling across the soil types present. Paddock history is also important, in terms of variation in management that could affect soil carbon, e.g., fertiliser inputs, drainage, effluent application and cropping. These elements are present within the farmlet systems at SDH, so we designed a sampling strategy to capture this variation.

We sampled 44 of the 104 research farm paddocks in May 2023. This consisted of six 50mm diameter soil cores and two soil bulk density measurements (100mm diameter) in each paddock, sampled from a random area within each paddock. These were divided into three depth increments: 0-75, 75-150 and 150-300 mm for analysis of total carbon concentration, total nitrogen concentration and soil mass per unit volume. Carbon stocks are the product of carbon concentration × soil mass, and 300 mm is the minimum depth recommended in international guidelines.

The results highlighted two key points:

- First, that there is considerable variation within a soil type – total carbon stocks for the Waikiwi soil varied from 112 – 148 tC/ha; for the Pukemutu soil from 100 – 116 tC/ha; and for the Makarewa soil from 85-107 tC/ha. This influences the number of sampled paddocks required to statistically detect change over time.

- Second, there were differences in the mean soil carbon stocks associated with paddocks with and without effluent application, paddocks with a high vs low N fertiliser history, and paddocks with or without a cropping history. However, only the comparison between effluent and non-effluent paddocks (on the Waikiwi soil) of approx. 7 tC/ha was statistically verified. That result implies that this is the level of change over time that will be detectable with our sampling regime.

Other things can also change over time. Soil compaction is evident on the farm, given that we are only seven years beyond the full cultivation and re-grassing that occurred when the farm was converted. This is why sampling multiple depth increments is important. If you sample to the same depth in a more compacted soil, you are not sampling the same mass of mineral soil, and this will skew the assessment of carbon stocks. Bulk density measurements in depth increments enable a correction for this effect.

ClieNFarms – modelling low GHG systems

Cecile de Klein, Andre Mazzetto, Mariana Barsotti, Alvaro Romera, (AgResearch)
Taisekwa Chikazhe, Lydia Farrell (DairyNZ)

Introduction

- ClieNFarms is a large European Union (EU)-based research programme to co-develop locally relevant solutions to reach climate neutral/carbon-zero and climate-resilient farms
- It aims to integrate and improve existing solutions to achieve economically viable systems
- NZ, along with 15 EU countries, is studying a range of sectors (dairy, beef, horticulture, poultry etc.)
- SDH is one of the global dairy demonstration farms – with funding from the NZ government
- NZ objectives of ClieNFarms:
    - Assess the greenhouse gas (GHG) footprints of the proposed new SDH research farmlets;
    - Use farm systems modelling to identify additional options and practices that could move the farmlets closer towards carbon-zero;
    - Assess the impact of these options on operating profit;
    - Develop marginal abatement cost curve and upscaling of results (in collaboration with Massey University).

GHG emissions, C footprints & operating profits of the proposed farmlets

We used the proposed SDH farmlets as baselines (Figure 14) and modelled the systems in Farmax to estimate on-farm GHG emissions. We also estimated the 'cradle-to-farmgate' milk carbon footprint using Ag:LCA, AgResearch's life cycle assessment tool.

Wintering / Intensity	Crop-based (fodder beet)	Grass-based (silage/baleage)
Standard (SI) N fert ~180 kg N/ha 3 cows/ha Standard per cow production	**SI crop wintering** Cows outdoors year-round On crop during winter 87 ha	**SI housed wintering** Cows indoors in winter (2 months) Fed grass silage 78 ha
Lower (LI) N fert ~60 kg N/ha 2.5 cows/ha Higher per cow production	**LI crop wintering** Cows outdoors year-round On crop during winter 61 ha	**LI baleage wintering** Cows outdoors year-round On pasture and baleage in winter 61 ha

Figure 14: Proposed SDH farmlets focussing on crop vs grass-based wintering and farm intensity levels (standard vs lower).

The on-farm sources of GHG emissions considered by Farmax include:

- Methane from enteric and manure emissions
- Nitrous oxide from urine, dung, manure and fertiliser
- Carbon dioxide from urea fertiliser

The cradle-to-farmgate milk carbon footprint assessment considers the same sources, but also includes the following additional on-farm and pre-farm GHG sources:

- On-farm fuel and electricity use
- Pre-farm: production and transport of farm inputs (feed, fertiliser, lime and pesticides)

The on-farm GHG emissions (tCO2e/ha) and milk carbon footprints (tCO2e/t MS) of the lower intensity farmlets were ~ 13% and ~ 8% lower than those of the standard intensity farmlets (Figure 15). There was little effect of crop vs baleage-wintering on these emissions.

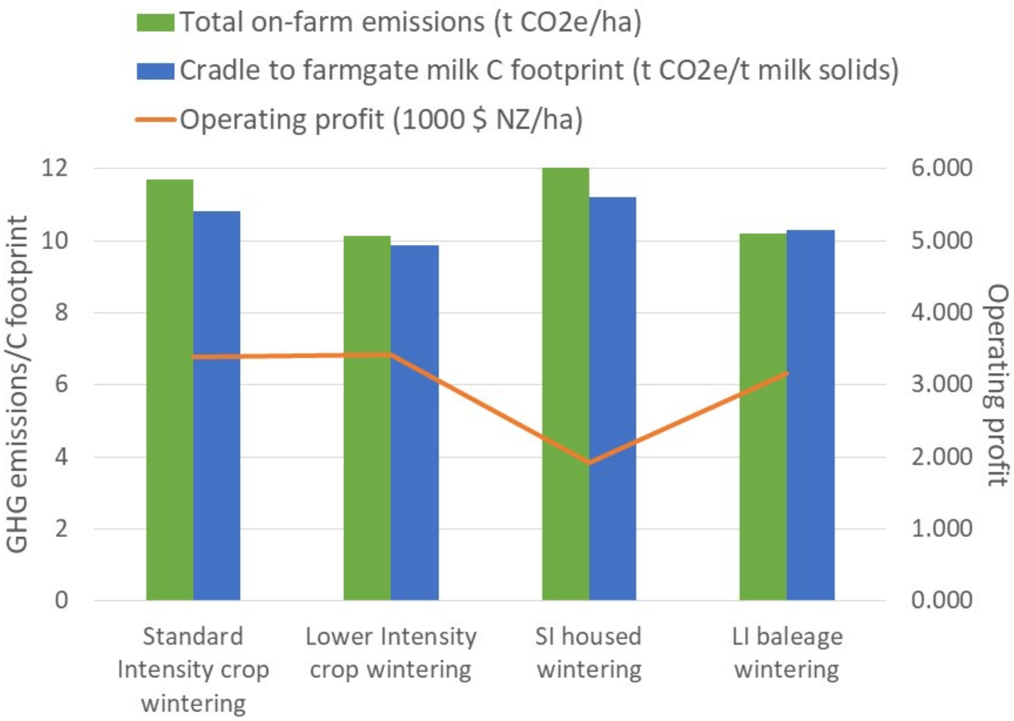


Figure 15: Total on-farm GHG emissions (green bars), cradle to farm gate milk carbon footprints (blue bars), and operating profits (at $7.50/kg MS; orange line) of the proposed SDH farmlets. On-farm emissions and operating profit were estimated using Farmax, and the milk carbon footprint with AgLCA, AgResearch's life cycle assessment tool.

Operating profit of the farmlets were similar, except for the proposed housed system due to repayment of the capital investment.

Results – scenario modelling for 2030

We also used Farmax to model scenarios for the systems in 2030 with different stock numbers. These were then assessed for impacts on on-farm emissions and operating profit. AgLCA was again used to assess the milk C footprints of these scenarios.

The two main 2030 scenarios were:

1. 2030 animal genetics, plus *reduced* stock numbers compared with the 2023 baseline, whilst maintaining total milk production.
2. 2030 animal genetics using the *same* stock numbers as the 2023 baseline, thus increasing total milk production.

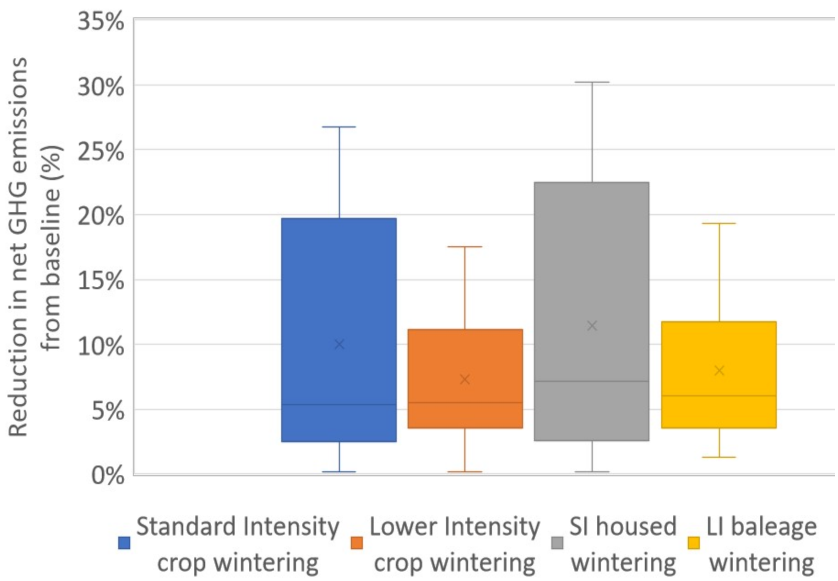
Under scenario 1, on-farm GHGs were reduced by 4% compared to the 2023 baseline. There was no change in GHG emissions in scenario 2. Operating profits in 2030 increased by 6 and 16% for scenarios 1 and 2 respectively, compared with the 2023 baselines.

We then added various GHG mitigation options to these 2030 scenarios, either individually or in combinations:

3. Replacing PKE with locally grown barley grain
4. In-setting trees for C sequestration on 1-4% of the farm area
5. Using a cash crop (e.g. hops) on 1-4% of the farm area
6. Removing all N fertiliser from the system (stock numbers were adjusted to match the reduction in pasture growth)

Take home messages

- 30% less GHG emissions is possible with current options for standard intensity (SI) systems. The 'No N fertiliser' scenario achieved the largest reduction, especially when combined with 'In-setting trees' (Figure 16).



With currently available options, up to 30% reduction in GHGs for SI systems; up to 20% reduction for LI systems)

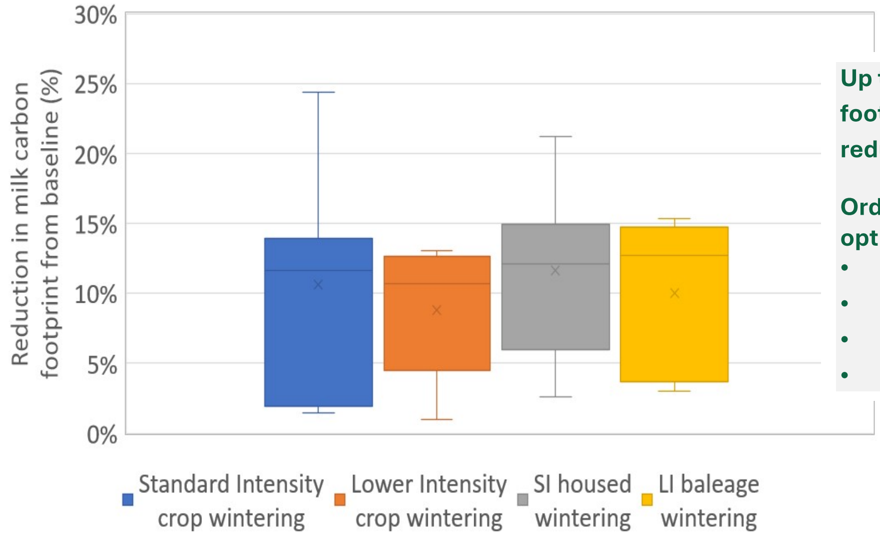
Reduction potentials were larger for standard intensity farmlets

Order of most promising options:

- **No N fertiliser**
- **Trees**
- **Cash crop**
- **Replace PKE with barley**

Figure 16: Modelled reductions (%) in on-farm GHG emissions compared to the 2023 baseline of the 4 proposed farmlet systems.

- 20% lower milk carbon footprint is possible for SI systems, with ‘replacing PKE with locally grown barley grain’ having the largest reduction, especially when combined with ‘No N fertiliser’ (Figure 17).



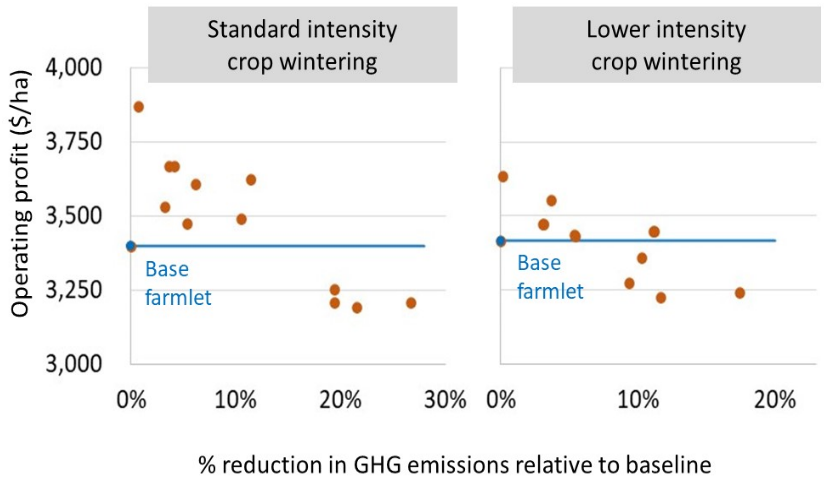
Up to 25% reduction in milk C footprint for SI systems; 15% reduction for LI systems

Order of most promising options:

- **Replace PKE with barley**
- **No N fertiliser**
- **Trees**
- **Cash crop**

Figure 17: Modelled reductions (%) in cradle to farmgate milk carbon footprint compared to the 2023 baseline of the 4 proposed farmlet systems. The graph represents the average (x), the median (horizontal line), and the maximum (top line) and minimum (bottom line) reductions.

- All scenarios were profitable, although profitability tended to decline with reducing GHG emissions (Figure 18).



Trade-off between GHG reduction and operating profit, but all systems still profitable.

The ‘No N fertiliser’ scenario had the lowest profit.

Figure 18: Modelled reductions (%) in on-farm GHG emissions versus modelled operating profits (at $7.50/kg MS; before tax and rent) of the various scenarios for the standard intensity and the lower intensity crop wintering farmlet systems. (Note: graphs do not include scenarios with hops, as profit estimates too uncertain)

- A focus on the efficiency of milk production will provide resilience for achieving on-farm GHG emission and milk C footprint targets.

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