Sheep liveweight and dry matter production from Years 3 and 4 of the Regenerative Agriculture Dryland Experiment

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Abstract

In Year 4 of Lincoln University's Regenerative Agriculture Dryland Experiment, the Regenerative sheep production system of multispecies forages and short-duration, high-density rotational grazing produced 130 kg/ha less liveweight than the Conventional system of simpler forages and longer-duration, lower-density grazing. Both systems produced the same amount of total dry matter (9.93 t/ha), but the Regenerative system produced less legume dry matter (3.43 versus 5.09 t/ha), crude protein (1.85 versus 2.24 t/ha) and metabolisable energy (111 versus 119 GJ/ha). The two levels of soil Olsen P (10–15 and 20–25 mg/kg) had no influence on the farm system effect. These results demonstrate that the greater legume content for the Conventional system was the most important factor to influence liveweight gain in this dryland environment.

Keywords: *Dactylis glomerata, Medicago sativa*, multispecies, rainfed, soil fertility, sustainability, *Trifolium subterraneum*

Introduction

Regenerative agriculture seeks to restore soil health, increase biodiversity and sequester carbon (C) to combat climate change (Rowarth et al. 2020; Giller et al. 2021; Grelet et al. 2021; Khangura et al. 2023; Cosgrove et al. 2024). It promotes diverse pastures and crops, rotational grazing techniques and minimum tillage to rebuild soil organic matter and improve ecosystem resilience. These practices are claimed to maintain productivity with minimal inorganic fertiliser input by recycling nutrients between soil, plants and animals (Grelet et al. 2021). The soil is also expected to have a greater water-holding capacity and therefore improved resilience to water deficits. Given the east coast of New Zealand is expected to become drier and warmer as climate change occurs, finding resilient farm systems to cope with summer dry and drought conditions is a major step in future proofing rural communities in these areas. Robb et al. (2025) reported 131 kg/ha less liveweight gain in Bohepe sheep from regenerative compared with conventional dryland systems in Year 3 of the Regenerative Agriculture Dryland Experiment (RADE) at Lincoln University, with no effect of soil phosphorus (P) level. This paper adds animal and forage production from Year 4 (2024–25) of the RADE.

Materials and Methods

A detailed description of the experimental design and management, including sowing rates and species mixtures, are given in Robb et al. (2025) and briefly described here with management details for Year 4 explained in detail.

A 2 × 2 factorial experiment is in progress at Lincoln University, New Zealand (43°38'54.20"S, 172°27'34.30''E, 9 m above sea level). The experiment compares a regenerative system against a conventional system for dryland (rainfed) sheep production as the first factor. The two systems are replicated across soils of two Olsen P levels (10–15 and 20–25 mg/kg in the top 75 mm) to examine the impact of P fertiliser as the second factor.

The Regenerative system combines regenerative practices promoted to dryland sheep farmers in New Zealand. Specifically, multispecies pastures and forage crops, short-duration and high-density rotational grazing techniques, with higher residuals than conventional systems, limited tillage, alternative fertilisers, and no pesticides. The Conventional system follows current best-practice recommendations for dryland sheep production. It involves lucerne (*Medicago sativa* L.) monocultures and cocksfoot/sub clover (*Dactylis glomerata* L./*Trifolium subterraneum* L.) pastures, annual ryegrass monocultures (*Lolium multiflorum* Lam.) forage crops, longer-duration and lower-density rotational grazing, limited tillage, conventional fertilisers, and herbicides.

The four treatment combinations are randomised across 80 small paddocks (plots) within five 4 × 4 Latin squares. Each treatment occurs once in each row and once in each column of paddocks in each Latin square. Paddock size is 0.087 ha for Square 1 (Plots 1–16) and Square 2 (Plots 17–32), 0.132 ha for Square 3 (Plots 33–48) and 0.089 ha for Square 4 (Plots 49–64) and Square 5 (Plots 65–80). Twenty paddocks of the same treatment make up one autonomous farmlet of 1.936 ha.

The experiment was established between December 2021 and June 2023 and further details of the pasture management have been reported previously (Watson et al. 2024; Robb et al. 2025).

The forage system on each Regenerative farmlet is

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10–12 multispecies-with-lucerne pastures (MSL; 50–60% of the farmlet), eight multispecies-with-balansa clover (*Trifolium michelianum* Savi) pastures (MSBC; 40% of the farmlet) and two annual multispecies crops comprising of annual brassicas, annual legumes, herbs, and annual ryegrass (AMS; up to 10% of the farmlet). The Conventional system has 10–12 lucerne monoculture pastures (L; 50–60% of the farmlet), eight cocksfoot/sub clover pastures (CSC; 40% of the farmlet) and two annual ryegrass monoculture crops (AR; up to 10% of the farmlet). The MSL and L pastures are assigned to Squares 1, 2 and 4, the MSBC and CSC pastures to Squares 3 and 5 for direct comparisons between the forage types. The AMS and AR crops are assigned to two rows of paddocks per year as part of a pasture renewal programme. The crop rotation is old pasture → AMS or AR crop → either a second crop or new pasture. The aim is for old pasture to be cultivated, and the crop sown by mid-March depending on rainfall. The annual crop is grazed two or three times over winter early spring and then cultivated, for new pasture to be sown in October–November. The tillage is limited to two paddocks per year in both systems. Hay is harvested from two MSBC or CSC pastures when surpluses develop in December (Rows 1 and 2 of Square 3) and fed out to overcome winter, and summer—autumn feed deficits as required.

The grazing regime for the Regenerative system is rotational grazing with a high density of sheep for a short duration (2–4 days) in each paddock. This is achieved with a single main mob of mixed-age ewes. The Conventional system is also rotationally grazed, but with a lower number of sheep for a longer duration (4–8 days) in each paddock. Each system is grazed with a separate mob of mixed-age ewes, split into two mobs/treatment for the Conventional system. This includes winter forage, which is break-fed with the duration differences being applied to 'days/break'.

On 11 July 2024, the mean Olsen P was 14 mg/kg for Low fertility treatments and 21.5 mg/kg for High fertility treatments. Therefore, P and S fertilisers were applied across all plots post grazing in the period 12 September to 16 October 2024 (mean: 25 September). On 10 July 2025, mean soil Olsen P was 15.5 and 24.5 mg/kg for Low and High fertility farmlets across both farm systems.

During the establishment phase (Years 1 and 2), Coopworth ewes grazed Latin Squares 1 and 2 from 16 February to 18 March 2022, then Coopworth ewe lambs, growing to hoggets, grazed the full experiment to 3 March 2023, followed by new Coopworth ewe lambs up to 7 August 2023.

In Year 3, 80 Bohepe ewes were introduced between 1 and 30 August 2023 (mean: 6 August). The Bohepe breed is a composite of wild sheep breeds, East Friesian, Finnish Landrace, Wiltshire and Merino, bred to create a short tail, bare breach, low-cost, easy-care sheep (Beattie 2022). Specific animal management for Year 3, including mating details, is fully described in Robb et al. (2025).

In Year 4, from 1 July 2024 to 30 June 2025, there were 96 pregnant Bohepe ewes and 16 pregnant hoggets rotationally grazing the experiment (24 ewes and 4 hoggets per farmlet). Therefore, both Regenerative and Conventional systems were stocked at 14.5 sheep/ha. The Regenerative sheep were managed as one flock of 28 sheep and the Conventional sheep were split into two mobs of 14 sheep to create the short-duration, high-density versus longer-duration, lower-density rotational stocking practices. This continued for the entire experimental period.

The mean lambing date was 1 September 2024. Weaning occurred on 3 December 2024. The number of ewes lambed, and lambs raised on each farm are given in . From weaning, the lambs grazed ahead of ewes in a leader-follower system, until 31 March 2025 when replacement ewe lambs were added into ewe mobs for mating where they remained as one mob for the rest of the season.

All lambs were weighed at weaning (3 December 2024). Maternal ewe and ram lambs were identified and retained for breeding: six ewe lambs/farm, one ram from High Conventional, one from Low Regenerative, and one from High Regenerative. The maternal ram lambs were removed on 18 December 2024. These maternal animals were shorn on 17 March 2024.

At weaning all non-maternal lambs were classified as 'trade' lambs. Any lambs that were not predicted to reach the target ≥36 kg were classified as 'store' lambs and sold off the experiment to a commercial farm on 18 December 2024. The remaining trade lambs were classified as 'prime' lambs and were sold to a local meat processer on 14 January 2025 and 25 February 2025.

The ewes were shorn on 17 December 2024. The ewes and hoggets were mated with one maternal ram per mob on 31 March–9 April 2024, then with one terminal South Suffolk ram per mob on 9 April–24 April 2024, and finally one maternal ram per mob from 24 April–5 May 2024. The winter break grazing by the

Table 1 Number of ewes that lambed and lambs raised for Regenerative (R) and Conventional (C) systems at High (H) and Low (L) soil fertility in Year 4 (July 2024–June 2025).

	HR	HC	LR	LC
Ewes lambed	23	24	24	23
Lambs weaned	40	40	42	44
Lambing %	174	167	175	191

ewes started on 12 May 2024, with 2-day breaks around all pastures and crops.

The Regenerative pastures were topped post grazing from 1 July 2024 to 15 March 2025 (to 6–8 cm) to remove reproductive stems, with the clippings left on the pasture to decompose as recommended by the technical advisory group in their review of Year 3, to maintain pasture quality under a high residual grazing system. Conventional pastures in Latin Squares 3 (Plots 33–48) and 5 (Plots 65–80) were topped during the same period to control reproductive grass seedheads. Typically, each plot was topped once, and usually no more than three times during the year. Decisions to top a complete Latin square were made after grazing the first row. Newly spring-sown pastures were topped after the first grazing with a chopper and cage to remove stems of the annual weed fathen (*Chenopodium album* L.) for all four farmlets. In this instance material was removed to reduce the weed pressure.

In Year 4, the hay was made in Plots 33–36. The Regenerative pastures (multispecies with balansa clover) were closed on 19–21 September 2024, and the Conventional pastures (cocksfoot/sub clover) on 17 September 2024. The hay was cut to 6–8 cm on 24 November 2024, wilted and then baled into conventional small bales, typically 18–24 kg, on 1 December 2024.

Due to a feed surplus in mid–late summer, Plots 9–16 were closed between 17–22 December 2024, then cut to 6–8 cm on 3 February 2025, and baled into conventional small bales on 9 February 2025. The bales were stored in separate stacks for each farm, and pasture type to be fed to sheep on the same farmlet as needed.

The 2024 winter crops, in Plots 1–4, were tilled on 16 October 2024 to 0–10 cm with a Howard rotary hoe on a John Deere tractor to break down plant crowns/turf, then drilled into lucerne for Conventional or multispecies with lucerne for Regenerative on 4 November 2024. Plots 49–56 were tilled initially on 22 January 2025, and then 4–7 February 2025 and drilled into annual ryegrass for Conventional or annual multispecies crops for Regenerative on 10 February 2025.

In Year 4, the weed and pest control was:

- Hand grubbing of nodding thistle (*Carduus nutans* L.), Scotch thistle (*Cirsium vulgare* (Savi) Ten.) and horehound (*Marrubium vulgare* L.) across all four farms throughout the year.
- 1.6 L/ha Terb 500 (500 g/L terbuthylazine) + 0.1 L/ha Pulse Penetrant (>800g/L organomodified polydimethyl siloxane) + 200 L/ha water on each lucerne pasture in Square 1, 2, and 4 between 11 July and 6 August 2024 following grazing.
- 4 L/ha Dockstar (asulam) on lucerne Plots 55 and 56 on 25 September 2024, and 59 and 60 on 26 September 2024 in the Conventional farmlets. 1 L/ha BioShield *(Serratia entomophila)* on Plots 9, 13, and 15 (Conventional) and all Regenerative plots in Latin Square 2 on 6 June 2025 for grass grub (*Costelytra giveni*) control.

Climate data were obtained from a NIWA meteorological station at Broadfield (Agent No. 17603 and 45751), 2 km north of the experiment (Earth Sciences New Zealand 2026). The long-term mean (LTM; 2002–2022) annual rainfall is 625 mm and ranges between 34 mm in September and 64 mm in June. For Year 4, the annual rainfall of 894 mm was greater than the LTM. Rainfall from July to December was similar to the LTM, with 45% less rainfall in November that created an early summer dry period of no pasture growth. However, mid-summer, and autumn rainfall were 210 mm higher in Year 4 than the LTM. Annual Penman potential evapotranspiration (PET) totalled 906 mm, being only 12 mm higher than the annual rainfall.

Soil water deficit was quantified in the top 0.5 m of the soil (Figure 1). Soil water content in the top 0.5 m of the soil was measured every 2–3 weeks by Time Domain Reflectometry (Trace System, Soil Moisture Equipment, USA) with 0.5-m probes installed in the centre of the plot.

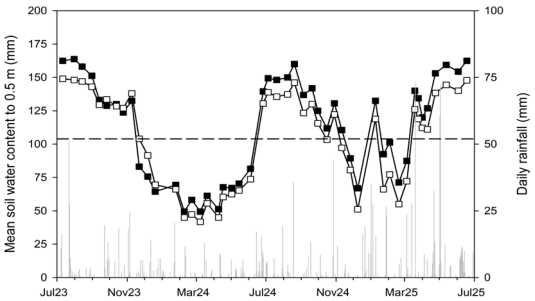


Figure 1 Daily soil water deficit in the top 0.5 m of the soil and rainfall for Regenerative (closed symbol) and Conventional (open symbol) dryland systems averaged across two soil Olsen P levels and daily rainfall (grey bar) from Year 3 and Year 4. Values less than 50% plant-available water content (dashed line) indicate water stress.

Carcass yield was calculated as the sum of the carcass weights provided by the meat processor. Carcass weight was summed by treatment, then averaged by farm. Liveweight yield was summed for each individual animal of all stock classes between weigh dates (usually the start of every month, or removal from farm) and then averaged across treatment and farm. Wool yield was bulked for each treatment and then averaged across the farm level treatment.

Herbage mass was determined before and after defoliation of each plot (e.g. grazing, cutting, tillage) and from all plots monthly. A representative 0.5 m^2

quadrat was selected within each third of the longest axis of the plot. Any brassica plant with a bulb inside the quadrat was pulled out of the soil, cleaned and ground level was marked on the bulb. The rest of the herbage inside the quadrat was cut to 1–2 cm above ground with an electric sheep-shearing handpiece and placed with the bulb plants in one sack per plot. At the laboratory, any bulb was removed from the sample, washed, separated into species (bulb turnip or leafy turnip), cut latitudinally at the ground level and weighed in an oven tray. The rest of the sample was weighed fresh and thoroughly mixed. A subsample, typically 200 g for a pre-defoliation sample and 100 g for each other sample, was weighed into another oven tray and it, and any bulb were dried in a 65°C-oven for about 48 h. Another subsample of about 400 pieces was separated into each sown species, weed (unsown species) and dead material and dried at 65°C to determine the mass of each component. The total and component herbage masses were calculated daily as linear interpolants between the measured values. The change in herbage mass from one day to the next was the herbage yield and this was summed across growth periods within the year to calculate annual herbage yield. Values were balanced across plot size to give weighted means, as that the size of each plot is proportionately contributing to a farm average for DM, botanical, and nutritive yields.

Annual total dry matter (DM), legume DM, crude protein (CP) yield, neutral detergent fibre (NDF), and metabolisable energy (ME) yields are compared between systems where the pasture type is similar, grazing occurs at comparable times and managed similarly. 'Pasture type' is separated by the species in which the plot is in for the season. Permanent pastures for the Regenerative system are either MSL or MSBC and are compared with their counterparts from the Conventional system; L or CSC are only compared between pastures occurring in the same Latin square. In instances where pasture type changed in the season (i.e. from permanent pasture to annual crop or vice-versa) these plots were treated as a separate forage type due to different management from permanent pasture or other crops and are only compared between systems.

The dried composite samples of pre-grazing herbage were ground to pass through a 2-mm sieve and analysed for CP, NDF and ME contents by near-infrared spectroscopy. The three measures of nutritive value were calculated daily as linear interpolants between the measured values.

The data obtained from individual plots were analysed with general analysis of variance, with a treatment structure as System*Fertility and a block structure as Square/(Row*Column). The treatment means were separated either by Fisher's Least Significant Difference test at $P<0.10$ for annual animal yields (live weight, carcass weight, and wool) due to the lower level of replication as has previously been done for similar data (Black et al. 2007), or $P<0.05$ for all other variables. All analyses were carried out in GenStat (23rd Edition).

Results

The Regenerative system yielded 131 kg/ha less ($P=0.075$) live weight, 79 kg/ha less carcass, 2.3 kg/ha less wool and 1.50 t/ha more DM, which comprised 0.7 t/ha less legume, 0.20 t/ha less CP and 9.45 GJ/ha more ME, than the Conventional system in Year 3 (Table 2). In Year 4, the Regenerative system yielded 130 kg/ha less ($P=0.028$) live weight, 15 kg/ha less carcass, 2.2 kg/ha less wool and 0.77 t/ha less DM with 1.7 t/ha less legume and 0.4 t/ha less CP. There were no effects of soil Olsen P in both years.

The greatest difference in annual total DM, legume, and CP yields in both Year 3 and Year 4 came from the MSL and L pastures (Table 3). During Year 3 the MSL pastures yielded 1.5 DM/ha greater than L pastures ($P=0.030$). However, in Year 4 the difference in total DM yield was 1.5 /ha less for MSL compared with L pastures. In both seasons, legume yield was greater ($P<0.001$) from L pastures compared with MSL pastures, with CP yields following the same trend ($P<0.001$). In Year 3, there was no difference in the ME supply ($P=0.299$) between the MSL and L pastures, but in Year 4 there was 12 GJ /ha less ME from the Regenerative MSL pastures compared with the Conventional L pastures ($P=0.021$).

Additionally, the annual legume yield from MSBC pastures was greater ($P<0.001$) in both seasons (Table 3) compared with the CSC pastures despite no difference in the total DM yield, CP, ME, or NDF yield ($P>0.05$).

Stocking rate (sheep/ha) from the 2 years of the experiment (Figure 2) shows that lambs on Regenerative farmlets were retained for a longer duration through the season compared with lambs on Conventional farmlets. The stocking rate of lambs declined from December 2023 to January 2024 at a slower rate for Regenerative farmlets (Figure 2a) compared with Conventional farmlets (Figure 2b). The stocking rate contribution from lambs became equal at 5 sheep/ha from the end of February until wintering off at the start of May across both Regenerative and Conventional systems. In Year 4, this difference was delayed until January, where again Regenerative farmlets retained a higher stocking rate of lambs compared with Conventional farmlets until the end of February when only replacement ewe lambs remained.

Table 2 Annual yield of live weight (LW), carcass weight (CW), wool, total dry matter (DM), legume DM, crude protein (CP) and metabolisable energy (ME) for Regenerative and Conventional dryland systems, averaged across two soil Olsen P levels, in Year 3 (2023–24) and Year 4 (2024–25).

Year	System	LW kg/ha	CW kg/ha	Wool kg/ha	Total DM t/ha	Legume DM t/ha	CP t/ha	ME GJ/ha
Year 3 (2023–24)	Regen.	496	78	18.1	8.40	2.60	1.39	91.0
	Conv.	627	157	20.4	6.90	3.33	1.59	81.0
	SED	37.6	27.5	0.546	112.6	162.7	48.8	3.94
	P Value	0.075	0.101	0.051	0.004	0.046	0.055	0.138
Year 4 (2024–25)	Regen.	717	114	19.9	9.50	3.43	1.85	111
	Conv.	847	129	22.1	10.3	5.09	2.24	119
	SED	22.3	10.27	0.711	501.6	150.5	64.3	6.00
	P Value	0.028	0.280	0.086	0.283	0.008	0.025	0.310

SED: standard error of the difference

Table 3 Annual yield of total dry matter (DM), legume DM, crude protein (CP), metabolisable energy (ME) and neutral detergent fibre (NDF t/ha) from permanent pasture and annual crops; multispecies with lucerne (MSL), lucerne (L), multispecies with balansa clover (MSBC), cocksfoot/sub clover (CSC), annual multispecies (AMS) and annual ryegrass (AR), in Year 3 (2023–24) and Year 4 (2024–25).

Year	Crop	Total DM t/ha	Legume DM t/ha	CP t/ha	MEGJ/ha	NDF t/ha
Year 3 (2023–24)	MSL	7.92	3.20	1.36	85.3	3.46
	L	6.42	5.97	1.90	79.0	1.51
	SED	0.664	0.479	0.116	5.99	0.428
	P Value	0.030	<0.001	<0.001	0.299	<0.001
	MSBC	9.21	3.16	1.59	110	3.69
	CSC	8.25	0.81	1.20	91.9	4.13
	SED	1.469	0.791	0.232	13.14	0.817
	P Value	0.522	0.008	0.109	0.187	0.593
	AMS-MSBC	3.96	0.49	0.84	63.9	2.11
	AR-CSC	2.29	0.98	0.86	60.3	2.18
	SED	2.155	0.460	0.276	20.9	1.394
	P Value	0.472	0.341	0.948	0.872	0.961
	[1]MSL-AMS	0.43	0.00	1.44	88.0	3.5
	[1]L-AR	0.48	0.00	1.87	82.5	1.8
	SED	0.113	-	0.367	15.61	0.813
	P Value	0.716	-	0.286	0.739	0.074
Year 4 (2024–25)	MSL	7.98	3.33	1.74	98.0	2.67
	L	9.46	9.41	2.47	110	2.49
	SED	0.491	0.332	0.094	4.99	0.272
	P Value	0.005	<0.001	<0.001	0.021	0.503
	MSBC	10.9	4.44	1.97	121	3.95
	CSC	10.5	1.62	2.00	123	4.33
	SED	1.072	0.505	0.197	11.40	0.527
	P Value	0.722	<0.001	0.880	0.874	0.481
	AMS-MSL	6.94	2.46	1.74	115	3.34
	AR-L	4.94	4.04	1.65	95.0	3.09
	SED	1.432	0.233	0.295	26.8	1.101
	P Value	0.297	0.021	0.775	0.518	0.844
	[1]AMS-AMS	12.0	0.67	2.07	135	4.15
	[1]AR-AR	15.2	0.00	2.16	162	7.76
	SED	0.770	0.073	0.107	9.39	0.512
	P Value	0.054	0.011	0.469	0.103	0.020
	[1]MSL-AMS	4.00	6.57	1.72	108	2.82
	[1]L-AR	4.71	0.00	2.87	140	4.32
	SED	0.981	0.002	0.122	7.89	0.259
	P Value	0.549	0.107	0.011	0.056	0.029

[1]Annual crop yields for the entire crop period may sit outside of the date ranges but are reported in the year of sowing. SED: standard error of the difference.

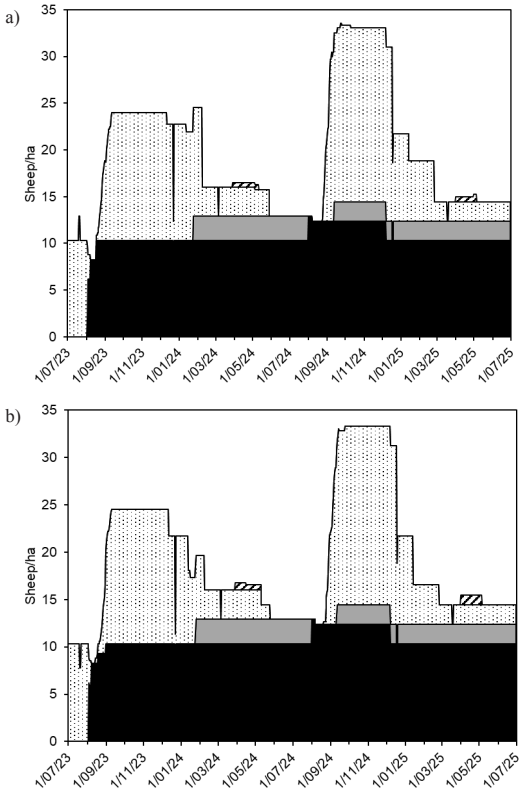


Figure 2 Stocking rate (sheep/ha) for (a) Regenerative and (b) Conventional systems by stock class from 1 July 2023 to 1 July 2025 (Year 3 and Year 4). Solid black- ewes, solid grey- hoggets, dotted black- lambs, dashed black- rams

Discussion

The mean annual farm production differences across the 2 years were 130 kg/ha less live weight and 2.2 kg/ha less wool from the Regenerative system compared with Conventional systems. In Year 3, there was 79 kg/ha less carcass weight from the Regenerative system compared with the Conventional system, but in Year 4 there was only a 15 kg/ha less carcass weight from Regenerative systems. This means that in Year 4, the increase in live weight production came from stock retained on the farm sold as trade 'store' lambs. Early sale of lambs in response to a dry period in late spring (Figure 1), followed by summer rain meant the breeding flock of the Conventional system was able to gain greater weight and condition. Higher pasture allocations and greater ewe weight pre-mating have clear relationships with greater ovulation rates (Kenyon and Webby 2022) and therefore may be a result of greater ewe weights in the Conventional system in Year 5 of the experiment. These results indicate a consistent production disadvantage from the Regenerative system across two seasons with contrasting soil moisture availability (Figure 1) and pasture management techniques.

Topping pastures during Year 4 of the experiment contributed to the reduction in difference between pasture yields from Regenerative and Conventional pastures. Grelet et al. (2021) explains a principle of regenerative grazing is to ensure pasture is maintained in a vegetative state. This was identified as a potential reason for lower pasture quality during Year 3 of the experiment (Robb et al. 2025) and during Year 4 topping was employed to manage this as integrating another stock class (such as cattle) is limited due to the experimental design. Topping pastures during periods of anthesis has been demonstrated to reduce dead matter content of pastures in summer and autumn from 44 to 21–35%, and temporarily reducing herbage accumulation immediately post topping (McDonald 1986). Adding topping into the regenerative management for Year 4 reduced the level of grass seedhead, and chicory (*Cichorium intybus* L.) stem, which were contributing to the lower pasture quality in Year 3 from the Regenerative system. Despite reducing the difference between annual pasture yield at the farm level, it did not alter the difference in annual liveweight production (Table 2), suggesting that it is not the quantity of pasture on offer, but the quality of pasture on offer.

Dryland systems have been developed to use pastures which provide both optimal animal production and multi-year persistence for continued long term gains (Moot 2012; Mills et al. 2014a, b). Annual animal production from the RADE in Year 3 and Year 4 was consistent despite the difference in rainfall (Figure 1). This highlights the resilience of the system based on lucerne monocultures and cocksfoot in this environment. Annual pasture yield increased under both treatments from Year 3 to Year 4, and with this annual liveweight yields (Table 2), which aligns with shorter periods of moisture stress during Year 4 (Figure 1), leading to greater annual production. Annual variability in rainfall influences pasture and live weight yields in dryland systems, with dry years expected to yield less pasture and liveweight compared with years that experience a lower maximum potential soil moisture deficit (Mills et al. 2014a, b). These studies highlight that soil moisture content influenced pasture yields between years, but the quality of feed on offer, related to the amount of legume in pastures, explained animal production differences in each year.

Annual DM yield from MSL pastures was 1.5 t/ha greater than L pastures in Year 3. Despite this, legume content, CP, and liveweight production were lower for the Regenerative system compared with the Conventional systems (Table 2). The lucerne grazing system is designed so that the quality of feed on offer is maximised and timed to match animal demand with

grazing initiated at, or shortly after lambing (Jones et al. 2024; 2025). This ensures that lactating ewes have sufficient feed of sufficient quality to maximise lamb growth and maintain ewe condition, as demonstrated by the ability to sell lambs off farm earlier for the Conventional system compared with the Regenerative system (Figure 2). The dryland system has been refined to maximise liveweight gains and prioritise pasture quality, whereas the regenerative treatment used in this experiment is designed to have multipurpose pastures that maintain ground cover and provide benefits to "soil health". These aspects are being monitored and will be reported in later publications.

The greater annual legume content from MSBC pastures compared with CSC pastures (Table 3), despite no difference in total yield, or nutritive value, has likely come from a difference in pasture growth habits. Sub clover (present in the CSC pastures) is a winter annual, having a specific use in a dryland system supporting early season production (Hyslop et al. 2003; Smetham 2003). A pasture containing sub clover has a different use in the grazing system compared with pastures containing perennial legumes intended for year-round legume supply, meaning that annual performance of cocksfoot/sub clover mixes does not show its value during lactation and the lamb growth period.

Therefore, the key pastures likely contributing to the observed reduction in legume and CP in the Regenerative systems were observed in the difference between the MSL and L pastures. This is consistent with previous research in dryland systems, that has demonstrated lucerne monocultures and cocksfoot/sub clover have greater liveweight production compared with other dryland grass based mixes, with grass based pastures producing the majority of their annual live weight in spring (64–70%), and lucerne producing 57% in spring, and the rest in summer (Mills et al. 2014a). The persistence of the legumes in grass based dryland mixes has been demonstrated to affect the long-term use of these mixes to support liveweight and DM yield (Mills et al. 2019). Further investigation into the seasonal production patterns of these pastures sits outside the scope of this paper but are ongoing to validate these conclusions.

Mean legume DM yield of the Regenerative MSL pastures was 2.8 and 6.1 t/ha lower in Year 3 and Year 4 than in the Conventional L monocultures. This meant CP yield was also 0.5 and 0.8 t/ha lower in Year 3 and Year 4 from the mean of the MSL pastures (Table 3).

Closing the gap between the protein supply of the optimised Conventional dryland system, and the Regenerative system with a 'multispecies multipurpose' approach will be the determining factor as to whether this Regenerative system could be applied successfully in an on-farm dryland context. Previous research into multi species swards which focus on higher quantities of legumes in the system have shown promising gains in this area when compared with conventional ryegrass/white clover (*Lolium perenne* L./*Trifolium repens* L.) mixes relative to lamb pre-weaning gains (Hutton et al. 2010; Kenyon et al. 2017; Maxwell et al. 2023) and maintaining greater gains through increased species persistence in the long term (Maxwell et al. 2023). However, these experiments have been under irrigated contexts, which highlights the need to look at different species mixes with an emphasis on legumes and drought tolerant herbs to increase the protein supply to ewes to optimise lamb liveweight production in dryland systems. Investigation into apparent intake, digestibility of feed both annually and seasonally is an ongoing output from this experiment.

The Conventional system was comprised of between 50–60% lucerne throughout the year, which has previously been recommended for dryland farms but is seldom achieved in practice. However, similar transformational change has been observed on farm with a smaller proportion of developed lucerne pastures (Avery et al. 2008). Similarly, Moot et al. (2024) explained the 'Bog Roy' farm system, which developed 265 ha out of 2,860 ha of land area into lucerne and cocksfoot/sub clover mixes over 11 years. This produced increases in lamb weight weaned by ewes, wool production, scanning percentages and quantity of lamb meat weaned. The Regenerative system on the RADE, provides a higher quality diet compared with undeveloped dryland pastures of browntop (*Agrostis capillaris* L.), or other similar grass monocultures, but the multispecies mix was unable to maintain enough legume to match the animal production measured from the Conventional system.

Conclusion

Liveweight, carcass, and wool production from Bohepe sheep grazing the dryland Regenerative systems were lower compared with those on the Conventional dryland system over two production seasons. These differences were caused by the higher quality of feed on offer from lucerne monocultures in the Conventional system, which supplied greater quantities of legume for a higher proportion of CP, and lower proportion of NDF annually. Future research into the quality of feed on offer during the important spring lactation period, the efficiency of the use of feed, and investigation of water use efficiency resource of these pastures will help provide further evidence to reinforce these claims.

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