Modelling methane emissions from Merino lambs on improved forages in low rainfall mixed farming systems

Brian Dzoma
SARDI, Minnipa Agricultural Centre

RESEARCH

Location:
Minnipa Agricultural Centre, competition paddocks
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2016 Total: 391 mm
2016 GSR: 268 mm
Livestock
Enterprise type: Mixed cropping and livestock
Type of stock/breed: Merino sheep

Key messages

- **Grazing vetch and lucerne can be used as a management strategy to improve lamb dry matter intake and growth rates during the late spring and early winter feed gaps.**
- **The Grazfeed decision support tool has predicted that while both legume forages (vetch and lucerne) will increase methane output (gCH_4/day), there is a reduction in methane output per unit of animal product (gCH_4/day/100gADWG).**
- **Moisture limitations can affect herbage production of lucerne, which in turn reduces the chances of growing lambs to achieve the full potential dry matter intake in low rainfall mixed farming systems.**

Why do the trial?

The issue of enteric (from intestines) methane (CH_4) emissions produced by ruminant livestock is gaining local and global interest due to methane being a powerful greenhouse gas and ruminants being a significant source of emissions. In the absence of measurements, prediction models can facilitate the estimation of enteric methane emissions from ruminant livestock and aid investigation of mitigation options. In Southern Australia, the management of the feedbase in low rainfall mixed farming systems through addressing 'feed gaps' – times of year during which the supply of forage is insufficient to meet livestock demand; is a key practice change which has the potential to mitigate methane emissions, particularly from sheep.

The aim of this trial was to evaluate pasture/forage options with a potential to fill the late-spring and early winter feed gaps and to measure comparative animal production and feed quality in response to current and improved forages. Methane output (gCH_4/day) was simulated using the GrazFeed model.

The GrazFeed decision support tool is a component of the GRAZPLAN decision support project for Australian grazing enterprises developed by CSIRO to help graziers improve the profitability of livestock production through more efficient use of pastures and supplementary feeds. It does this by predicting the intake of energy and protein and their use for maintenance and production (Freer *et al.,* 1997).

How was it done?

Replicated field trials were established at Minnipa Agricultural Centre, Minnipa, EP, SA (Lat: 32° 50'11" S; Long: 135°09'05" E) in June (winter trial) and October (spring trial) 2016. The winter grazing trial commenced on 1 June with 100 Merino wether lambs (July/August 2015 drop) at an average liveweight (LW) of 37 kg, split equally into two treatment groups of 50 animals. The lambs were weighed on 1 June following an overnight fast and treatment 1 lambs were placed on 3 ha of lucerne and treatment 2 lambs on 1.5 ha of self-sown oats. The lambs were taken off treatments for shearing and fat and eye muscle scanning on 14 June and taken back to treatments on 17 June. Final LW measurements were done on 5 July 2016 following an overnight fast.

The spring grazing trial commenced on 28 September with 60 Merino wether lambs (July/August 2016 drop) at an average LW of 28 kg, split equally into two treatment groups of 30 animals. Lambs were weighed on 28 September and treatment 1 lambs placed on 1 ha of green vetch at podding stage, supplemented by oaten hay; and treatment 2 lambs on 1.5 ha of a mature self-sown oats crop, supplemented by lupins in a lick feeder. Lambs were taken off treatments on 27 October and final LW measurements were done the following day. For both grazing trials, forages were tested for dry matter (DM) availability and forage quality (FEEDTEST analysis) (Table 1).

Table 1 Treatment details and fodder/pasture quality

Phase	Stock type/age	Grazing days	Treatment	Diet supplement	Dry matter (%)	Crude protein (% DM)	Digestibility (%)	ME (Mj/kgDM)
Winter 2016	Merino lambs (~12 months)	31	Lucerne		92.6	27.8	70.1	11.1
			Self-sown oats (green)		93.5	23.4	73.9	11.3
Spring 2016	Merino lambs (~5 months)	30	Vetch	Vetch	23.4	17.2	74.1	11.1
				Oaten hay	86.8	9.6	66.4	9.8
			Mature self-sown oats	Self-sown oats	44.5	7.1	64.1	9.4
				Lupins (grain)	92.8	29.8	82.5	13.3

In previous grazing trials (EPFS Summary 2013, 2014, 2015), methane output was measured using a polytunnel supplied by CSIRO (WA), however for the winter and spring 2016 grazing trials, GrazFeed was used to estimate LW gain and DM intake (DMI), then simulate methane output (gCH_4/head/day) in relation to DMI, DM digestibility and protein percentage.

What happened?

There was a high response ($P<0.001$) in LW gain and animal growth rate, to the forages offered in both grazing trials. For winter 2016, the lambs grazing lucerne consumed an estimated 1.69 kg DM/lamb/day and achieved an Average Daily Weight Gain (ADWG) 20% higher (204.7 g/head/day) than the lambs grazing self-sown oats (163.4 g), shown in Table 2. DMI for the lambs on lucerne was lower because intake was being limited by the quantity of herbage on offer, which was too low (average of 1.4 t DM/ha) for the potential intake to be achieved. The 20% difference in growth rate can be attributed to the fact that the self-sown oats crop, which was lower in protein (no fertiliser inputs), deteriorated in quality as the crop matured, and resulted in a slower gut passage time due to poor digestibility of the fodder. For spring 2016, the lambs grazing vetch at podding stage had a higher DMI (1.39 kg DM/head/day) than the ones on the mature self-sown oats (1.08 kg DM/head/day), and achieved higher ADWG (154.2 g/head/day) because of higher digestibility (%), crude protein (%) and metabolisable energy (ME, MJ/kgDM).

GrazFeed predictions (Table 3) were close to the actual calculated estimates for DMI and LW gain. However, there were bigger differences in predicted LW gains for spring 2016 with GrazFeed estimating mean LW gain (g/head/day) of 24 g and 199 g for lambs on the mature self-sown oats and vetch respectively, as compared to actual calculated estimates of 8 g and 154 g for the same forages.

For both grazing trials, winter and spring 2016, LW gain for these lambs was not being limited by the concentration of protein in their diet. This is indicated in Table 3 by the surplus in the intake of rumen degradable protein and undegradable protein. Lambs on lucerne had the highest surplus rumen undegradable (202 g) and degraded protein (69 g). For winter 2016, gain efficiency was higher for lambs on lucerne (47%) than lambs on self-sown oats; and for spring 2016 it was higher for lambs grazing vetch (56%).

Table 2 Forage intake and liveweight gain

Phase	Fodder	Fodder intake (kg DM/head/day)	Average LW gain (kg/head)	Ave Daily Weight gain (g/head/day)
Winter 2016	Lucerne	1.69	6.6	204.7
	Self-sown oats (green)	1.78	5.2	163.4
	LSD ($P<0.001$)		*0.8*	*23.5*
Spring 2016	Vetch	1.39	4.6	154.2
	Mature self-sown oats	1.08	0.2	7.6
	LSD ($P<0.001$)		*1.1*	*36.2*

Table 3 GrazFeed simulations for DMI (kgDM/head/day), ADWG (g/head/day), degradable protein (g) and maintenance and gain efficiency (%)

	Parameters	Winter 2016		Spring 2016	
		Lucerne	Self-sown oats (green)	Vetch	Mature self-sown oats
DM Intake *(kgDM/head/day)*	Actual calculated estimate	1.69	1.78	1.39	1.08
	GrazFeed estimate	1.70	1.71	1.34	0.90
Mean LW gain *(g/head/day)*	Actual calculated estimate	205	163	154	8
	GrazFeed estimate	213	176	199	24
GrazFeed outputs	Maintenance efficiency (%)	71	72	72	68
	Gain efficiency (%)	47	37	56	34
	Surplus rumen degradable protein (g)	202	138	184	37
	Surplus undegradable protein (g)	69	65	62	20

Simulated methane output

The GrazFeed model was used to simulate the changes in methane output (gCH_4/day) in response to the improved pastures that have the potential to fill early winter and late spring feed gaps. Methane emission intensity, defined as the amount of methane produced per unit of livestock product, was assessed based on the LW performance of the sheep in their respective treatments and was standardized relative to 100 g ADWG over the grazing period.

There were no differences in total methane output between lambs on lucerne or self-sown oats (winter 2016), but for spring 2016, the lambs on vetch were producing 13% more methane than the ones grazing a mature self-sown oats crop. Methane emission intensities (gCH_4/day/100gADWG) were higher on the legume forages than cereals for both grazing trials. For every 100 g of ADWG the lambs on vetch were producing 0.78 gCH_4/hr, compared to 11.46 gCH_4/hr for the lambs grazing mature self-sown oats (Figure 1).

What does this mean?

Feed gaps are key limitations for improving livestock productivity in most regions of Australia's mixed farming systems. Management practices that can reduce the frequency or intensity of a major feed gap can greatly improve the profitability of a livestock enterprise by reducing the amount of supplementary feeding and/or increasing the livestock numbers without the risk of overgrazing. Assuming lamb prices (cents/kgLW) for Merino wethers averaging 40 kg and 29 kg are 279 cents and 334 cents respectively (Auctionplus, 2017), the LW gain would represent a dollar benefit of $18 for lambs grazing on lucerne, $15 on green self-sown oats, $15 on vetch and only $1 for lambs grazing mature self-sown oats for the 30-day grazing period. For this trial, filling the spring feed-gap with a better quality green feed (vetch) resulted in a $14 difference in dollar benefit between green vetch and mature self-sown oats. While improving the availability and digestibility of forages offered to lambs during critical feed gaps can increase growth rates and enteric methane output (g/day) produced by growing sheep, it can also bring significant reductions in methane emissions per unit of animal product. Alcock and Hegarty (2011) showed that if farmers use sheep with 10% higher growth rates, methane emissions are reduced by about 3%. For the two grazing trials, lucerne and vetch proved to be better options to fill the winter and spring feed gaps by maximizing animal productivity with lower methane emission intensities.

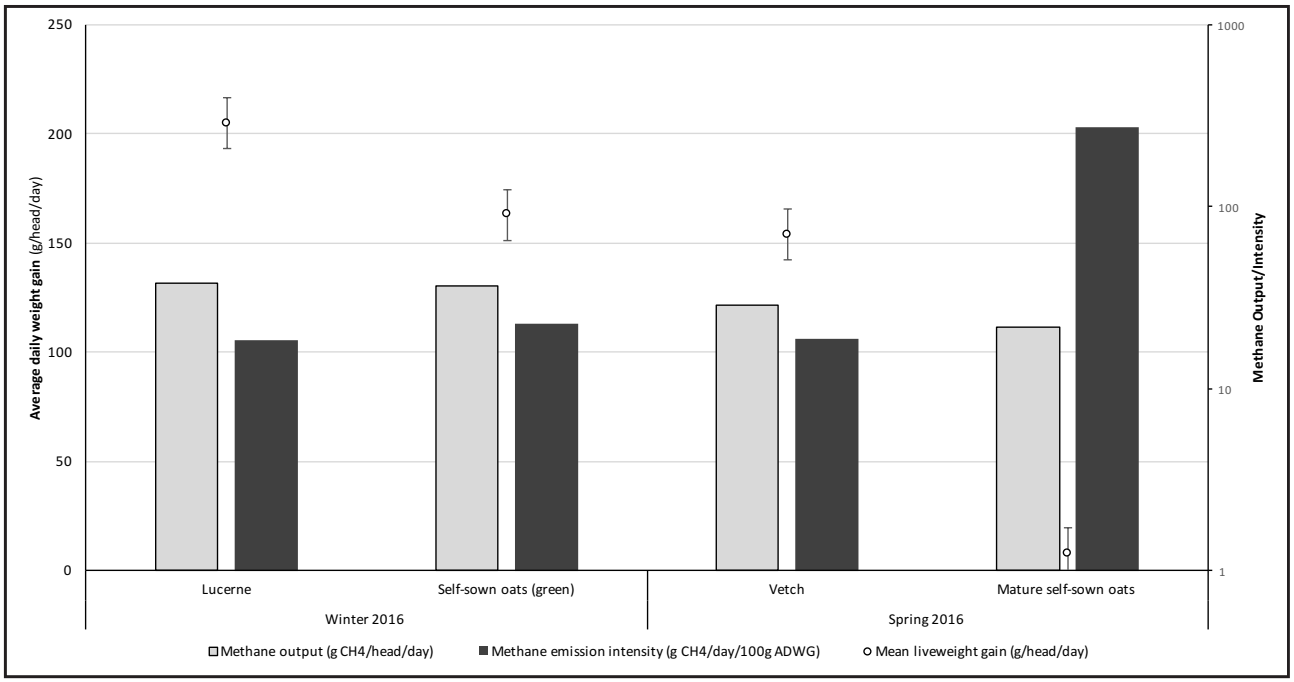

Figure 1 Mean liveweight gain (g/head/day), methane output (gCH_4/head/day) and methane emission intensity (gCH_4/day/100gADWG)

The GrazFeed decision support tool has proved that in the absence of real-time polytunnel methane measurements it can be used to identify critical relationships between lamb productivity and methane output relative to the availability and quality of the different forages offered.

Acknowledgements

Thanks to Jake Hull, Wade Shepperd and John Kelsh for managing the livestock and setting up trial infrastructure; Jessica Crettenden for livestock handling and sheep data management. This project is supported by funding from the Australian Government Department of Agriculture – Action on the Ground program (Project Code: AOTGR2-0039 Reducing sheep methane emissions through improved forage quality on mixed farms).

References

Alcock, DJ & Hegarty, RS (2011). Potential effects of animal management and genetic improvement on enteric methane emissions, emissions intensity and productivity of sheep enterprises at Cowra, Australia. *Animal Feed Science and Technology*, vol. 166–167, pp. 749–760

AuctionPlus (2017). Weekly livestock market comments. https://auctionsplus.com.au/livestock-market-comments. Accessed on 30/01/2017

Freer M., Moore A.D and Donnelly J.R (1997). GRAZPLAN: Decision support systems for Australian grazing enterprises. II. The animal biology model for feed intake, production and reproduction and the GrazFeed DSS. Agricultural Systems 54: 77-126