BRIEF COMMUNICATION: Substitution of perennial ryegrass with forage rape reduces methane emissions from sheep

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Introduction

Methane (CH_4) emissions from pastoral livestock is the largest single contributor to the greenhouse gas inventory in New Zealand (NZ) (Ministry for the Environment 2013), which could pose a risk to the image and long-term sustainability of the sector. Because of their high feeding values, forage brassicas (*Brassica* spp.) are increasingly used in NZ to feed ruminants in winter and summer (Barry 2013). Forage brassicas fed as pure swards have resulted in lower CH_4 emissions from sheep relative to sheep fed ryegrass (*Lolium perenne*) pasture, with forage rape (*B. napus* L.) having the greatest effect on the emissions (Sun et al. 2012). However, in practice, forage rape is not always offered as a sole diet to sheep and feeding mixtures of forages might change the extent of the CH_4 mitigation effect. The aim of this study was to determine CH_4 emissions from sheep fed ryegrass substituted with increasing levels of forage rape in the diet.

Materials and methods

Sheep for this trial were adapted to the diet at the AgResearch Aorangi Experimental Station and indoor CH_4 measurements were performed at the AgResearch Grassland Research Centre, Palmerston North, NZ. All animal manipulation protocols were approved in advance by the Grassland Animal Ethics Committee (approval no. 13225).

Experimental design

A single factorial experiment was conducted with five treatments consisting of increasing proportions of forage rape substituting for perennial ryegrass. The treatments were FR0, FR25, FR50, FR75 and FR100, in which forage rape was 0%, 25%, 50%, 75% and 100% of the dry matter intake, with the remainder being ryegrass.

Animals

Seventy two six-month-old Romney male sheep (37.8 ± 1.54 kg, mean ± SD) were stratified by weight and randomly allocated to one of five diets. The four groups of sheep allocated to diets containing forage rape were adapted to forage rape in the paddock for 14 days, while the sheep in the treatment without forage rape were fed pure ryegrass for the whole experiment. During the indoor period, sheep were adapted to their designated diets in pens for 10-17 days and in metabolism crates for four days before CH_4 measurements. Freshly cut forages were provided in two equal meals (0830 and 1630 h), supplied at 1.6 times metabolisable energy (ME) requirement for maintenance (Australian Agricultural Council 1990). For purposes of this calculation, ME of forage rape was assumed to be 12 MJ/kg DM (Sun et al. 2012) and that of ryegrass (11.2 MJ/kg DM) estimated using near-infrared spectroscopy (NIRS) according to Corson et al. (1999) as described in detail by Sun et al. (2010).

Forage

The sward of forage rape (cv. Titan) was established on 27 March 2014 and harvested for the indoor experiment from 16 June to 8 July 2014. Ryegrass was harvested from an established pasture. Harvest was performed daily (1100 to 1230 h) leaving a stubble height of 7 cm using a Kuhn drum mower with a conditioner (Model PZ 220, Kuhn Farm Machinery (UK) Ltd, UK). Forage rape had a height of 53 cm and ryegrass 50 cm on average when harvested. The harvested forage rape contained 94% green leaves, 4% stems and 2% yellow and dead leaves on fresh weight basis, and ryegrass contained 78% green leaves and 22% yellow and dead leaves. These forages were stored at 4°C within 0.5 h after harvest and used for afternoon feeding on that day and for the next morning feed.

Methane measurements

Methane emissions were determined from each animal for 48 h in three batches using 24 respiration chambers installed in three clusters. The structure of the respiration chambers was described in detail by Pinares-Patiño et al. (2012) and the operation procedure was the same as described by Sun et al. (2012).

Feed sampling and laboratory analysis

Samples (*ca*. 200 g) from each forage cut were collected daily in triplicates and dried in a forced air oven at 105°C for 48 h for DM content determination. During the measurement periods of CH_4 emissions, an extra sample was collected, dried at 65°C for 48 h and ground through a 1-mm screen. The samples were pooled over each batch of CH_4 measurements for analysis of the chemical composition by Massey University Nutrition Laboratory (Palmerston North, NZ) as described by Sun et al. (2012) (Table 1).

Table 1 Chemical composition (g/kg dry matter, unless otherwise stated) of the diets of forage rape, perennial ryegrass and their mixtures.

	Percentage of forage rape fed with for perennial ryegrass (% of dry matter)				
Chemical constituent	FR0[1]	FR25	FR50	FR75	FR100
Dry matter content (g/kg fresh matter)	136	125	116	106	99
Organic matter	870	869	868	866	865
Crude protein	228	253	278	303	328
Lipid	37	35	32	30	28
Hot water-soluble carbohydrates	73	92	111	130	149
Pectin	12	31	50	69	88
Readily fermentable carbohydrates[2]	86	123	161	199	237
Neutral detergent fibre	518	434	351	267	183
Acid detergent fibre	270	236	202	168	133
RFC:SC[3]	0.17	0.61	1.04	1.47	1.91
Lignin	20	30	40	49	59
Gross energy (MJ)	17.1	17.1	17.0	17.0	16.9

[1] Forage rape percentage (FR %) in the diet mixture with perennial ryegrass. FR0, FR25, FR50, FR75 and FR100 are 0%, 25%, 50%, 75% and 100% of forage rape in the diet, in dry matter basis. [2] Hot water-soluble carbohydrates plus pectin. [3] Ratio of readily fermentable carbohydrates : structural carbohydrates (hemicellulose + cellulose).

Table 2 Methane emissions from young sheep fed fresh perennial ryegrass as a sole diet and substituted with varying amounts of fresh forage rape, measured over 48 h in open-circuit respiration chambers.

	Percentage of forage rape fed with perennial ryegrass (% of dry matter)						
Intakes and emissions	FR0[1]	FR25	FR50	FR75	FR100	SED	P value
Dry matter intake (kg/d)	0.806^{a}	0.910^{b}	0.931^{bc}	0.940^{bc}	0.978^{c}	0.0270	<0.001
CH_4 (g/d)	18.1^{d}	18.7^{d}	15.4^{c}	12.1^{b}	8.1^{a}	0.75	<0.001
CH_4 (g/kg dry matter intake)	22.5^{e}	20.5^{d}	16.5^{c}	12.9^{b}	8.2^{a}	0.79	<0.001
CH_4 energy loss/gross energy intake	0.073^{e}	0.067^{d}	0.054^{c}	0.042^{b}	0.027^{a}	0.0026	<0.001

[1] Forage rape percentage (FR %) in the diet mixture with perennial ryegrass. FR0, FR25, FR50, FR75 and FR100 are 0%, 25%, 50%, 75% and 100% of forage rape in the diet, in dry matter basis.

Statistical analysis

A one-way ANOVA was performed using GenStat for Windows (13th edition, VSN International, Hemel Hempstead, UK, www.genstat.co.uk) to analyse CH_4 emission data with forage rape proportion in the diet as the experimental factor and measurement batch as block.

Results and discussion

Feed intake increased as the percentage of FR increased and FR0 and FR25 were significantly lower than FR100, by 18% and 7%, respectively (Table 2). Daily CH_4 emissions were similar for FR0 and FR25, but decreased linearly (R^2=0.751, P<0.001) with increasing inclusion of forage rape. There were strong linear relationships (P<0.001) between percentage of forage rape in the diet and both the CH_4 emissions per unit of DM (CH_4 yield; R^2=0.938) and gross energy intake lost as CH_4 (R^2=0.940). Methane yield decreased by 0.145 g/kg DM for each 1% increase of forage rape in the diet. These results suggest that CH_4 mitigation can be achieved when ryegrass is substituted with forage rape in sheep diets.

The difference in CH_4 yield (8.2 versus 22.5 g CH_4/kg DM) between pure forage rape (FR100) and ryegrass (FR0) was larger than we found in previous studies [16.4 versus 22.0 g CH_4/kg DM reported by Sun et al. (2012); 13.6 versus 19.5 and 17.8 versus 22.9 CH_4/kg DM reported by Sun et al. (2015)]. The reason for the differences between trials is not known. However, it could be related to the lower DM content in forage rape in this study, compared with previous ones. Dry matter content appears to be correlated to CH_4 yield, i.e., CH_4 per unit of DM (Pacheco et al. 2014), so that forage rape with a low DM content could reduce CH_4 emissions by increasing the passage rate of liquid from the rumen.

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