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

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Keywords: forage rape; methane; perennial ryegrass; sheep

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).
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\textsubscript{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\textsubscript{4} emissions were similar for FR0 and FR25, but decreased linearly (R\textsuperscript{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\textsubscript{4} emissions per unit of DM (CH\textsubscript{4} yield; R\textsuperscript{2}=0.938) and gross energy intake lost as CH\textsubscript{4} (R\textsuperscript{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\textsubscript{4} mitigation can be achieved when ryegrass is substituted with forage rape in sheep diets.

The difference in CH\textsubscript{4} yield (8.2 versus 22.5 g CH\textsubscript{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\textsubscript{4}/kg DM reported by Sun et al. (2012); 13.6 versus 19.5 and 17.8 versus 22.9 CH\textsubscript{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\textsubscript{4} yield, i.e., CH\textsubscript{4} per unit of DM (Pacheco et al. 2014), so that forage rape with a low DM content could reduce CH\textsubscript{4} emissions by increasing the passage rate of liquid from the rumen.

Acknowledgements

This study was funded by Pastoral Greenhouse Gas Research Consortium (PGgRc), New Zealand. We thank Steve Lees, Derek Birch and Gregory Skelton for animal management during field adaptation, German Molano and Fiona Smith for technical assistance during the indoor experiment.

References


Sun et al. – Forage rape reduces sheep methane