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SEASONAL CHANGES IN METHANE EMISSION FROM NEW ZEALAND PASTURES - A SURVEY USING IN VITRO METHODOLOGY

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Abstract

A closed *in vitro* gas production system was used to measure enteric methane production from 314 New Zealand pasture samples taken from commercial farms across a 24-month period that covered two consecutive milking seasons (June 2017-May 2019).

Across the 24-month period, emissions were determined to range from 9.75 to 32.41 g methane per kilogram of dry matter (DM), averaging 21.09 g/kg DM with a standard deviation of 3.92. There were distinct periods between December and April (summer/autumn) in both seasons when the methane emission conspicuously decreased.

Introduction

There is currently a very large focus on greenhouse gas (GHG) from agriculture in New Zealand. Agriculture is said to contribute 48% of New Zealand's GHG profile, and a large part of this is from enteric methane production from the rumen (Ministry for the Environment, 2019). There is a lot of interest in determining carbon footprints (CFP) of ruminant production systems. A comprehensive study by the GLOBAL NETWORK project found that dry matter intake (DMI) is the single most important parameter to predict enteric methane production (Niu et al., 2018). One of the more popular methods used to estimate DMI uses an energy balance model that relates to animal production parameters (Undi *et al*, 2018).

Inherent in this approach is the assumption that all DMI is of equal energy value. However, metabolisable energy levels from pasture can vary based on several criteria, one of which is digestibility, and digestibility, while being multifactorial in nature, is related to seasonal effects. This is of critical importance in New Zealand where pasture is the key ingredient in ruminant production systems.

The current study looked at a large data set of gas production data, determined by *in vitro* fermentation, from a broad range of pastures taken from commercial New Zealand farms. The data was examined *a posteriori* to assess the effect of apparent dry matter digestibility across seasons on methane production.

Methodology

Pastures (n=314) were harvested from across New Zealand from commercial farms during a 24-month period (June 2017-May 2019).

Pastures were dried and subjected to an *in vitro* fermentation in a closed gas production system. To account for weekly variation in donor fluid, a known standard ration with known fermentation characteristics was fermented as part of each weekly fermentation to provide a weekly correction factor that was applied to metrics determined.

Donor rumen fluid was taken from a lactating dairy cow fed a pasture-based ration.

Dried samples of pastures (0.5 g) ground to a 2 mm size were incubated at 39^{o}C using a rumen-buffered inoculum for 48h (Mould *et al,* 2005). Rumen fluid to buffer ratio was 20:80.

During the incubation period, gas production was measured continuously using an automated pressure transducer system (IFM, Alltech).

Volatile fatty acid (VFA) concentrations were measured by gas chromatography (Erwin *et al,* 1967) on samples taken at 48h of incubation. The stoichiometry of Wolin (1960) was used to estimate methane production based on VFA production.

Results

Across the 24-month period there was a wide range in *in vitro* methane production. Emissions themselves were determined to range from 9.75 to 32.41 g methane per kilo of dry matter (DM), averaging 21.09 g/kg DM with a standard deviation of 3.92.

It was found at the macro level, the variations moved in response to seasons (figure 1). Methane production from pasture samples collected in summer and early autumn (December – April) were markedly lower compared to methane production from pasture samples collected during the rest of the year.

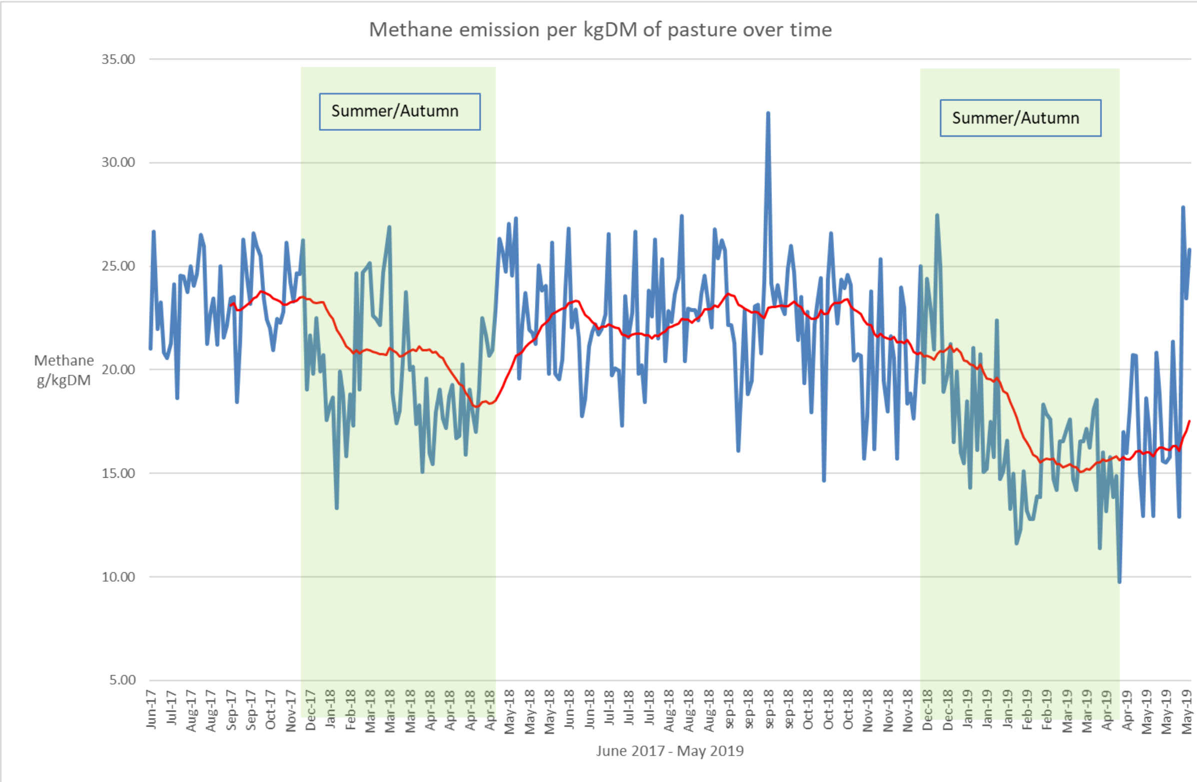

Figure 1: methane emissions determined *in vitro* from random pastures sampled across 24 months

In addition, the *in vitro* production of methane was highly related to digestibility, with a correlation coefficient of 0.76 ($p<0.01$, figure 2).

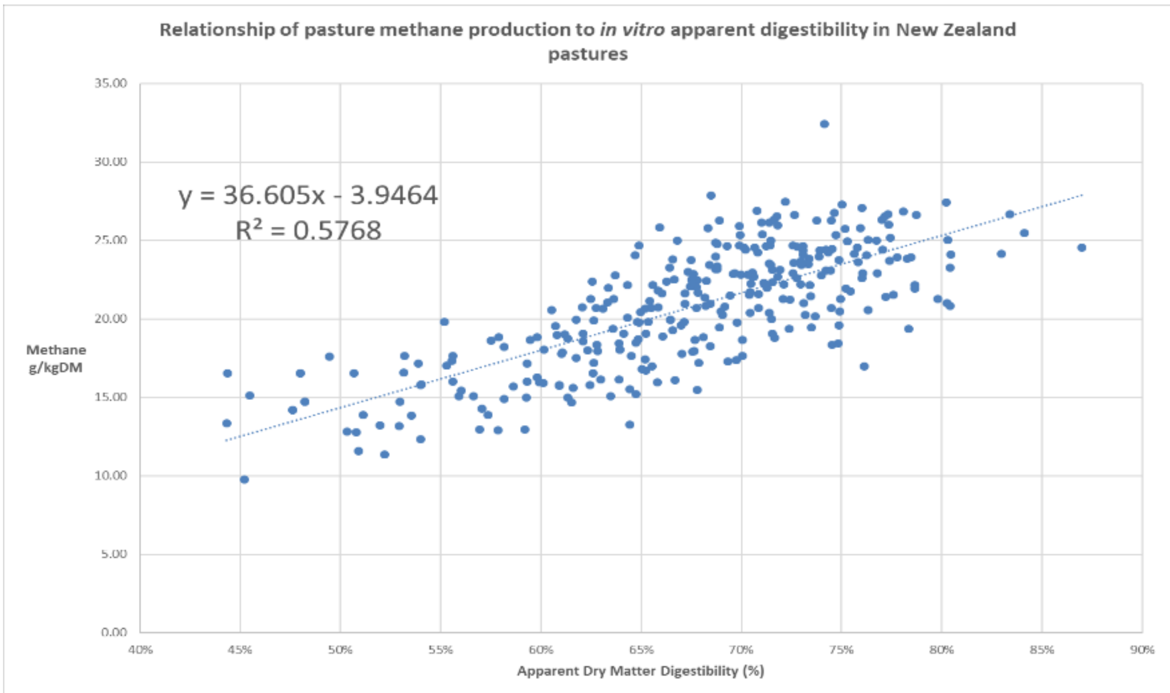

Figure 2: relationship between methane production (g/kgDM) and in vitro digestibility (%)

Discussion

The present work is broadly in agreement with the standard emission factor of 21 gCH_4 per kg DM that is reported as an average figure by the NZAGRC (2016).

However, there is a distinct period of the year – summer and early autumn- when this average emission factor substantially overestimates enteric methane emissions from pasture. When comparing methane emission per unit of dry matter it was found that emissions decrease in summer and autumn. It is well known that dry matter digestibility of pasture decreases in autumn when the pasture moves from a vegetative state to a reproductive state (McIvor, 1981, Mountousis, 2008). Chavez *et al*, (2006) suggest the decreasing digestibility as pasture matures is due to a change in the proportions of stem, leaf and inflorescence, as opposed to changing chemical composition within these components *per se*. Furthermore, it was previously reported digestibility in pasture based total rations was related to chemical components of the whole ration (Meads *et al*, 2020)

It is known that in some animal production systems animals also have a lower DM intake (DMI) at this time of year, and lower DMI can be a function of animal demand but is also likely influenced by lower digestibility slowing down the rate of passage of the digesta (Chavez *et al*, 2001).

Our work suggested that in certain circumstances there may be scope to further refine the use of a standard figure for methane emission based on a kg of DMI. When combining the seasonal effect with between farm variation, the current data set shows that experimentally determined individual farm emission factors can vary from the average by a range of +54% through to –55%. The implications of this work are that there is capacity to improve the accuracy of individual farm estimations and presents the opportunity to increase the accuracy of carbon calculator models.

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