GreenFeed and Sniffer Standard Operating Procedure (SOP) in dairy and beef cattle

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Abstract

Enteric methane emissions from ruminants are a major contributor to atmospheric greenhouse gas accumulation. Accurate measurement of methane production in ruminants is crucial to not only develop reliable national greenhouse gas emission inventories, but also evaluate mitigation strategies for methane emissions. Measuring actual enteric emissions in livestock is complex, expensive and time consuming. Many different research and industry bodies globally are investigating the feasibility and accuracy of a range of different techniques for recording enteric methane emissions. Amongst the techniques available, GreenFeed (*C-Lock Inc. Rapid City, SD, USA*) and sniffer systems are the most common. The objective of this study is to describe standard operating procedures for GreenFeed and sniffers in measuring enteric methane emissions in dairy and beef cattle leveraging the expertise and experience of those operating the equipment in a range of different settings; the procedures were share and discussed through meetings organized by the ICAR Feed and Gas Working Group. Standard operating procedure items of interest include, amongst others, animal training protocols and adaption period length, number of animals per machine, equipment troubleshooting and upgrades. Experiences collected will be part of the ICAR Methane Emission Recording Guidelines update.

Keywords: greenhouse gas emissions, data-collection, GreenFeed, sniffer.

Introduction

Enteric methane emissions from ruminants are a major contributor to atmospheric greenhouse gas accumulation. Accurate measurement of methane production in ruminants is crucial to not only develop reliable national greenhouse gas emission inventories, but also evaluate mitigation strategies for methane emissions. Measuring actual enteric emissions in livestock is complex, expensive and time consuming. Many different research and industry bodies globally are investigating the feasibility and

accuracy of a range of different techniques for recording enteric methane emissions. Amongst the techniques available, GreenFeed (*C-Lock Inc. Rapid City, SD, USA*) and sniffer systems are the most common.

Material and methods

Enteric methane (CH_4) production and carbon dioxide (CO_2) production can be measured non-invasively using a GreenFeed emission monitoring system (*C-lock Inc. Rapid City, SD, USA*). GreenFeed is an adapted feeding station that continuously measures both CH_4 and CO_2 concentration and the quantitative airflow in order to generate individual gaseous production. GreenFeed is equipped with a fan that pulls air from around the head of the cow with 30-40 L/s. The airflow is measured continuously by a hot-film anemometer that needs to be calibrated monthly. In the air collection pipe continuous subsamples are drawn to analyse the CH_4 and CO_2 concentration by nondispersive infrared sensors, which are automatically calibrated on a daily basis. Additionally, head positioning is registered by an infrared sensor. Temperature and radiofrequency identification tags specific to each cow for individual recognition are recorded as well. All variables are logged at a 1 s interval. GreenFeed measures continuously, even if there are no animals present, to correct for background emissions in the barn. The periods within a visit where the head position of the animal is correct are used for measuring gaseous emissions. Quantitative concentrations in g/d were calculated at a 1 s interval, which were then averaged per visit (minimum of 2 min).

Over years other instruments and techniques have been developed and used for research purposes. Between all instruments and techniques available, Sniffer method has assumed significance. Sniffer has been developed to measure and collect data about methane (CH_4) and carbon dioxide (CO_2) emissions in the breath of ruminants during milking and/or feeding. The feed bin might be in an automatic milking system (AMS) or in an automatic feeding system (AFS). Before considering all features, advantages and disadvantages of the system, it is important to remember that they have been originally designed to detect dangerous gas leaks. Breath-sampling methods are non-invasive because, once installed, animals are unaware of the equipment and animals are in their normal environment. Animals follow their normal routine, which includes milking and feeding, so no training of animals, handling or change in diet are required. Equipment is relatively cheap and running costs are negligible. In Sniffer method, gases are continuously sampled into a sampling tube installed in the feed bin or through. The other end of the sampling tube is connected to an infrared CH_4 and CO_2 concentration analyser. Data are collected every 1-5 seconds by the Sniffer.

This document is the report obtained from presentations, talks, chats and discussions of the Zoom meetings on 5th,7th December 2022 and 23rd February 2023. In all meetings an introduction was made about the *ICAR Feed and Gas Working Group*, the objectives of the Working Group, including the revision of the guidelines (*Section 20 - Recording Dairy Cattle Methane Emission for Genetic Evaluation*) published two years ago. Moreover, the aim of the meeting was to share knowledge on GreenFeed and Sniffer standard operating procedure including tips, tricks and trouble-shooting data recording.

Results

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Moreover, the aim of the meeting was to share knowledge on GreenFeed and Sniffer standard operating procedure including tips, tricks and trouble-shooting data recording.

1. Discussion is organized in four different paragraphs as follow:Equipment description;
2. Experimental protocols;
3. Training and adaptation period;
4. Problems faced and upgrades;

Discussion

GreenFeed equipment description

The correct placement of the GreenFeed unit inside the barn is crucial.

Indoor, it is advisable to place it on solid, non-slatted floor, in a location with good ventilation. Irregular ventilation or background emissions from manure may negatively affect the estimates of methane and carbon dioxide emissions.

Outdoor, the GreenFeed have to be located in a solid place (not in the mud), with a good phone (internet) connection and a good sunlight (if equipped with solar panel). The GreenFeed unit and the grazing site have to be nearby. The grazing area should not be so large as it could impact the number of visits. It may be appropriate to install an electric fence to protect the GreenFeed unit from animals' damage, but also to avoid animals to enter by side of the GreenFeed; this was not always undertaken and warrants further investigation. A plastic and waterproof cover can be installed on the unit and a weather station on its top. Together with the GreenFeed, the trailer can also be purchased from C-Lock. This trailer is suitable for short distance moving and it is essential for placement in pasture (i.e. the trailer contains a spot where the unit can be attached, since it has to be standing solid to prevent it from getting damaged by cows, where the gas cilinders can stand and contain power supply (solar panel or batteries). If it is necessary to move the GreenFeed unit for longer distances it is essential to have a more solid trailer available and should be compatible with the legal requirements for road vehicles in the respective country.

All users agree that wooden side shieldings provided by C-Lock are not enough to contain the animal and to reduce the influence of other animals' emissions. According to user experience to reduce influence of gaseous emissions from cows to the side, a good side shielding must be 0.80-0.90 m wide and adjustable, at least 2.5 m long, both indoor and outdoor.

Some advanced users have created a "L-port gate" that closes behind the animal, so it cannot be pushed out of the unit by other cows. Cows that use this "L-port gate" are calmer (once they are used to it).

All users consider positive the ventilation noise of the GreenFeed fan. This ventilation noise is easily associated by the animals with the supply of feed, so the animals adapt more quickly.

As regards the feed to be used in GreenFeed, most users use a pellet feed with a diameter of less than 7 mm as suggested by C-Lock. Few users use feed blocks.

Sniffer equipment description

On the market several suppliers of this product are available, but all systems share the same basic structure consisting of: gas meter, pressure inlet, flow meter, pressure outlet and a tube to suction with filter. It is essential to have a filter at level of the suction tube to avoid clogging of the cylinder with dust, saliva or feed. In the tube between the cylinder and the gas meter, whose diameter is 2-4 mm, one or more filters can be inserted which ensure the removal of impurities and debris from the animal's breath. For the correct functioning of the system and for the collection of good quality data, the aspiration pump must work with an aspiration volume of 0.5-1.5 L/s. In more complex systems and to deal with particular needs (e.g., high environmental humidity) a dryer tube can also be inserted. Generally, Sniffer systems are provided of at least two gas meters: one for the methane (CH_4) and one for carbon dioxide (CO_2); further gas meters could be available, e.g., oxygen (O_2) or nitrous oxide (N_2O). Gas cards used to estimate CO_2 and CH_4 concentrations have different sensitivities: 0-10.000 ppm for CH_4 and 0-50.000 ppm for CO_2. Internet connection is guaranteed through a 5G modem or through a Wi-Fi router. Internet connection allows data storage or download. Connections problems can occur; therefore, a hard disk can be provided to ensure data still collected when connection is lost.

It is important to install the Sniffer sampling tube in a position that is not so visible to the animal to avoid frequent damages.

If there are power cuts, the system restarts automatically when power is restored.

GreenFeed experimental protocols

The overall duration of the trial varies, from a minimum of 7 days up to a year, both indoor and outdoor, according to the purpose of the experimental trial. Feeding settings can vary dependent on the preferred feed gift and preferred number of measurements per day. There are two important principles that should be met: the time of a feeding period (and thus gaseous measurement) should be between 2 and 5 minutes (at least 2 minutes, preferably 3-4 minutes), and the number of visits per day should be between 2 and 8, and divided over the day. The number of cows that can visit multiplied by the number of visits per cow per day multiplied by the time per visit should never exceed 24 hours, but preferably not exceed 12 hours (which means occupation of the GreenFeed 50% of the time).

The wide variability of the experimental protocol variables can be summarized as follows:

Table 1. Indoor and outdoor protocols.

	Indoor	Outdoor
Drop dispense interval	10 - 60 seconds	10 - 30 seconds
Min. time between feeding periods	7.200 - 21.600 seconds (2 - 6 hours)	3.600 - 14.400 seconds (1 - 4 hours)
Max. drops per feeding time	4 - 25	4 – 25
Max. feeding periods	4 - 12	4 - 12

Sniffer experimental protocols

No particular experimental protocols are applied. Once installed, the system runs continuously.

Change in diet are not required.

GreenFeed training and adaptation period

The overall duration of the training and adaptation period last from 7 to 20 days, both indoor and outdoor. Animals that are already used to feeding boxes in the barn are generally easier to train to use the GreenFeed.

For all the adaptation period it is essential to locate the GreenFeed within the eyesight of the animals.

During training the “drop dispense interval” can be slightly adjusted, for example reduced to 10 seconds in first days of adaptation, then increased to 20 seconds and then it is possible to use the experimental protocol. Outdoor could be useful to provide a small amount of feed around the GreenFeed unit or near to the GreenFeed chute.

Using a camera installed on the top of the unit can be useful for training, so the user can drop feed when animals are near to the GreenFeed unit.

If using side shieldings, it is important to set the funnel at largest size and reduced regularly day by day up to the end of the training period and the start of the experimental trial.

In some cases, there might be animals that are more difficult to train. In this case it is good practice to guide them into the GreenFeed and evaluate their behaviour. If they are reluctant, it is advisable not to involve them in the experimental trial. Generally, 50% of the animals adapt autonomously, 25% of the animals need an intervention, and the remaining 25% are more reluctant. A good training and adaptation period provides for the success at least 70% of indoor animals and at least 50% of grazing animals.

Having non-users located beside users of machines has proven to be helpful when later training those non-users.

Spread concentrates in the chute or using salt licks may help entice animals to use the machine

When based on grazing, it is important that the machine is moved to the edge of the fresh pasture once strip wire is moved – animals should not have to move far to reach the machine as this will impact number of visits.

Sniffer training and adaptation period

Training, handling or adaptation period are not required.

Greenfeed problems faced and upgrades

Table 2 reports all the problems faced including solution and possible home-made upgrades found by the several institutions.

Table 2. tips and tricks.

Problem	Solution	Suggestions/upgrades
Feed clogging in the bin	Unclog the feed bin and try a more solid pellet. Prevent the feed bin from moist.	Extra molasses in feed pellet.
Motor problem	Replaced using C-Lock spare parts and assistance.	
Airflow problems	Replaced using C-Lock spare parts and assistance.	
Connectivity problem	Replaced using C-Lock spare parts and assistance.	In alternative, purchase an external Wi-Fi router or SIM-card router.
Power supply problem	Replaced using C-Lock spare parts and assistance.	
Batteries under solar panel are getting low and smart solar controllers decide battery is too flat.	Moving from lead acid to lithium iron phosphate ($LiFePO_4$) batteries has largely eliminated the problem. This is because $LiFePO_4$ give a constant output voltage.	
RFID identification problems	Caused by either low power supply (check and replace power supply if needed) or antenna problems (follow instructions from C-lock to find the cause and replace if needed).	
Leaky CO_2 cylinder and lower CO_2 release	Replaced CO_2 cylinder by C-Lock.	Make sure to never hold the CO_2 tool upside down when attached to a CO_2 cylinder.
Concentration sensor	Replaced using C-Lock spare parts and assistance.	
Shipping time and shipping issues in some parts of the world (e.g., Europe and Oceania)		List of “must have spare parts” to create a personal warehouse. European or Oceanian dealer?
Feed bin brush chewed by a rodent	Tack on feed bin chute.	Internal component more sealed.

Despite the various problems encountered, all users consider the assistance provided by the C-Lock very good (video tutorials, operating instructions...). E-mail reply is quickly (few hours considering time zone).

It is recommended to keep spare parts in stock.

Sniffer problems faced and upgrades

Device waterproof

Sniffer devices are not always completely waterproof. Considering that there is electrical wiring inside and that in some cases the intervention of a technician is necessary, it is important to choose an IP65 box or to equip the Sniffer box with a waterproof coating.

Clogging problems

To avoid clogging of the pipes, ideally a venting hose is provided. This pipe is connected to the compressed air outlet pipe of the AMS. When the gate of the milking robot opens, allowing the animal to exit, compressed air is blown into the venting hose. This air flow in the direction of the cylinder helps to avoid clogging.

Animals' identification

Antenna for ID reader is not always successful. It is suggested to use AMS data identification and merge them later on.

Calibration procedure

In many cases problems of calibration drift can occur. It is necessary to standardize zero and span calibrating procedure.

Personnel in charge of the trial

It is essential to have a good technician who monitors Sniffer's activities on daily basis and who also knows the AMS and AFS system. Among the activities that the technician must carry out: setting up, moving equipment, daily data monitoring and download, checking up on equipment at irregularities, fixing problems, downloading AMS data and ordering spare parts. If a good technician is not available, it is essential to have an alert system (sms, e-mail) of anomalies.

Filter replaces

Filter obturations by dust or condensation can occur. It is possible to prevent these problems changing external filter every 15 days and change internal filter every 6 months.

Conclusion

GreenFeed and Sniffer are two different systems, but to date they are the most reliable. The definition of SOP and ICAR Guidelines update are only first steps. Further steps will be data editing, trait definition, phenotypic and genetic analysis.