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THE INFLUENCE OF THE DAIRY COWS FEEDING ON THE METHANE AND CARBON DIOXIDE EQUIVALENT EMISSIONS FROM MANURE

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Abstract

The research purpose to demonstrate that feed rations can be a tool that would help the husbandry sector reduce greenhouse gases. The researches were realized on the Moara Domneasca farm on a flock of 27 dairy cows at different stages of Montbeliarde's lactation between November 2019 and September 2020. The dairy cows have been divided into lots which have been given different breeding flocks. The rations in the 6 variants were administered during the summer and winter seasons. The dairy cows are kept in free stabulation in a shelter and management system of manure were considered paddock, solid system and lagoon/slurry. The methane emission from manure management was calculated using tier 2 from the IPCC 2006, specific farm data are available for GE, DE, VS, and for B_0 and MCF were used default values. The results shows that methane and carbon dioxide equivalent emissions are the highest in variants 6 and 4 and the lowest in variant 1 with green fodder. Experimental variant of ration no. 1 and no. 5, which contain a large amount of green mass, show that methane emissions from manure management decrease compared to ration variations in which animals receive more concentrates feed.

Key words: *carbon dioxide equivalent, emissions, manure, methane.*

INTRODUCTION

Methane is the most abundant organic chemical in the earth's atmosphere, and its abundance is increasing with time and has reached levels not seen in recent geological history. Methane is produced both naturally and anthropogenically. One of teh sources of anthropogenic methane is manure from domesticated animals (Steed & Hashimoto, 1994).
Biogenic emissions of methane (CH_4) and nitrous oxide (N_2O) from animal manure are stimulated by the degradation of volatile solids (*VS*) which serves as an energy source and a sink for atmospheric oxygen (Someret al., 2004). Reducing short-lived climate pollutants is key to limiting global warming to 2°C above preindustrial levels (Shindell et al., 2012).
Arndt et al. (2018) shows that methane is a short-lived climate pollutant with 3 times the global warming potential (84 vs. 28) in the short term (20 yr) than the long term (100 yr; IPCC, 2013).
Consequently, the contribution of CH_4 to anthropogenic greenhouse gas is greater in the short term than in the long term (28 vs. 11%; US EPA, 2017b).

MATERIALS AND METHODS

The paper purposes to demonstrate that feed rations can be a tool that would help the husbandry sector reduce greenhouse gases. The researches were realized on the Moara Domneasca farm on a flock of 27 dairy cows at different stages of Montbeliarde's lactation between November 2019 and September 2020. The dairy cows have been divided into lots which have been given different breeding flocks. Each variant respect the physiological and productive needs of the animals. The rations in the 6 variants were administered during the summer and winter seasons. The dairy cows are kept in free stabulation in a shelter and management system of manure were considered paddock (0.6 which means 7.2 months for these manure system), solid system (0.35 which means 4.2 months only inside) and lagoon/slurry (0.05, half of months until is mixed with other type of manure for degraded into a manure composting platform). When the weather is favorable (more than 7 months per year), the animals are taken into the paddock.

The methane emission from manure management was calculated using *method* 2 from the IPCC 2006, specific farm data are available for GE, DE, VS. To estimate the methane emission according to method 2 (box 4 of the decision tree), we also using default values for B_0 and MCF.

For the calculation of methane emissions from animal waste management systems, ***equations 10.22., 10.23*** and ***10.24*** of the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 2006* were used.

$CH_{4\ MANURE} = \sum_{(T)} \frac{(EF_{(T)} * N_{(T)})}{10^6}$ (Ec. 10.22)

where:

$CH_{4Manure}$ = CH4 emissions from manure management, for a defined population, $GgCH_4$/year;

$EF_{(T)}$ = emission factor for the defined livestock population, kg CH_4 /head/year;

$N_{(T)}$= the number of head of livestock species/category T in the country;

T = species/category of livestock.

$EF_{(T)} = (VS_{(T)} * 365) * \left[B_{O(T)} * 0.67 kg/m3 * \sum_{S,k} \frac{MCF_{S,k}}{100} * MS_{(T,S,k)}\right]$ (Ec. 10.23)

where:

$EF_{(T)}$ = annual CH4 emission factor for livestock category T, kg CH_4 /animal/year;

$VS_{(T)}$ = daily volatile solid excreted for livestock category T, kg of dry matter/animal/day;

365 = basis for calculating annual VS production, days/year;

$B_{o(T)}$ = maximum methane producing capacity for manure produced by livestock category T, m^3CH_4/kg VS excreted;

0.67 = conversion factor of m^3 CH_4 to kilograms CH_4;

$MCF_{(S,k)}$= methane conversion factors for each manure management system S by climate region k, %;

$MS_{(T,S,k)}$ = fraction of livestock category T's manure handled using manure management system S in climate region k.

$VS = \left[GE * \left(1 - \frac{DE\%}{100}\right) + (UE * GE)\right] * \left[\left(\frac{1-ASH}{18.45}\right)\right]$ (Ec. 10.24)

where:

VS = volatile solid excretion per day on a dry-organic matter basis, kg VS/day;

GE = gross energy intake, MJ/day;

DE% = digestibility of the feed in percent (e.g. 60%);

(UE*GE) = urinary energy expressed as fraction of GE. Typically, 0.04 GE can be considered urinary energy excretion by most ruminants (reduce to 0.02 for ruminants fed with 85% or more grain in the diet or for swine).

ASH = the ash content of manure calculated as a fraction of the dry matter feed intake.

18.45 = conversion factor for dietary GE per kg of dry matter (MJ/kg). This value is relatively constant across a wide range of forage and grain-based feeds commonly consumed by livestock.

In the calculation of (UE*GE) fraction, urinary energy expressed as a fraction of the gross energy was made based on the equation developed by Hoffmann & Schiemann (1974):

Urine Kcal (% of GE) = $3.30 + 0.233\ x_1 + 0.016\ x_2 - 0.00002\ x_2^2 \pm 0.7$

X_1 = the GP (crude protein) content of the ration (% of dry matter);

X_2= body weight (in kg).

X_1 value is calculated based on an extremely simple algorithm consisting in reporting the crude protein amount to the amount of dry matter in the ration, expressing the result as a percentage. The amount of protein and dry matter in the ration are essential parameters in calculating its structure, and the values for each type of fodder can be taken from the tables with the chemical composition and nutritional value of various forage categories (Stoica, 1997).

Thereafter, the result is converted into MJ (1 kcal = 239 MJ) to enter in the equation10.24. For other parameters necessary for calculating the methane emissions from manure management systems, i.e.B_0 and MCF, will use default values in order to meet the conditions for method 2 of IPCC 2006 implementation (p.10.52).

The equation for calculating the entheric CO_2 emission shall be (Users' guide for estimating carbon dioxide, methane, and nitrous oxide emissions from agriculture using the State inventory tool, 2019):

CO_2 (kg/an) = (emission of CH_4 x 25 GWP) / 1,000,000,000

RESULTS AND DISCUSSIONS

The calculation of the GE and DE parameters was carried out on the basis of the rations administered in the 6 experimental variants using the chemical composition of the specified feed (Stoica, 1997).

The formula for calculating GE is:

$$GE\ (kcal/kg) = 5.72 \cdot PB + 9.5 \cdot GB + 4.79 \cdot CelB + 4.17 \cdot SEN$$

where:

GE = gross energy intake (kcal/kg);

PB = crude protein (%);

GB = raw fat (%);

CelB = crude fiber/cellulose (%);

SEN=non-nitrogenous extractive substances (%).

The rations have been formulated earlier according to the animal feeding schedule and the values of crude protein, crude fat, crude cellulose and non-nitrogenous extractable substances (Table 1) have been obtained from analyzes carried out in its own laboratory, i.e. by calculation (SEN).

Digestible energy (DE) is used to express the nutritional value of feeding stuffs and rations, especially for grazing animals.

Mathematical equations have been used to establish it by calculation, as in the case of raw energy, but in this case the digestibility content of nutrients is taken into account, taking into account the digestibility factors specific to each feed and species, namely taurine (Dragotoiu et al., 2017), then multiplied by the energy equivalents for digestible energy, which are different by species. In the table 1 are detailed the ration given to the dairy cows during the experimental period, according with lactation phases (upward, plateau and down ward phase).

The values obtained for methane emissions from manure management and the equivalent CO_2 emissions are given in Table 2, Figures 1 and 2, respectively.

For calculating methane emissions from manure management, the default value of B_0 (0.24), i.e. default values for MCF (0.01 for paddock, 0.02 for solids storage and 0.25 for liquid/sludge fraction) was used.

Table 1.The ration given to the dairy cows during the experimental period

Lactation phase	Up phase				Plateau phase						Down phase	
Exp. variant	V1		V2		V3		V4		V5		V6	
Feed	Feed (Kg)	Feed (%)	Feed (Kg)	Feed (%)	Feed (Kg)	Feed (%)	Feed (Kg)	Feed (%)	Feed (Kg)	Feed (%)	Feed (Kg)	Feed (%)
Lucerne hay	0	0	3.00	7.16	6.00	15.13	5.80	15.55	4.70	7.86	7.00	19.80
Hay clover	4.50	7.03	0	0	0	0	0	0	0	0	0	0
Corn soiled	0	0	27.33	65.23	15.00	37.83	25.00	67.04	0	0	17.30	48.95
Fodder beet	0	0	0	0	7.00	17.65	0	0	0	0	0	0
Beer Brewery	0	0	3.00	7.16	5.00	12.62	0	0	0	0	5.00	14.14
Spring bowl	28.50	44.55	0	0	0	0	0	0	33	55.23	0	0
Clover	23.60	36.89	0	0	0	0	0	0	17	28.45	0	0
Maise grain	5.70	8.91	2.30	5.49	3.10	7.82	4.60	12.34	2.80	4.68	2.50	7.07
Barley grain	1.00	1.56	2.20	5.25	2.20	5.55	0	0	2.20	3.68	2.20	6.22
Wheat bran	0.60	0.94	1.50	3.57	0	0	0	0	0	0	0	0
Sunflower meal	0	0	2.50	5.97	1.30	3.28	1.80	4.83	0	0	1.30	3.68
$CaCO_3$	0.07	0.11	0.07	0.17	0.04	0.10	0.06	0.16	0.03	0.05	0.04	0.11
$CaHPO_4$	0.01	0.01	0	0	0.01	0.02	0.03	0.08	0.03	0.05	0.01	0.03
Total	63.98	100.00	41.90	100.00	39.65	100.00	37.29	100.00	59.76	100.00	35.35	100.00
Ration contribution												
DM (kg)	17.45		17.91		19.82		17.31		15.86		16.94	
NEM (Mj)	104		102		99		98		99		94	
DEIN (g)	1728		1751		1587		1607		1623		1645	
DEIE (g)	1645		1601		1541		1575		1522		1526	
Ca (g)	159.68		111		115.28		114.72		155.01		123.02	
P (g)	61.86		74.81		54.34		57.65		70.00		53.91	

Table 2. The emission of CH_4 and CO_2 equivalent from manure management

Exp. variant	Head no.	GE (MJ/day)	DE (MJ/day)	Ash (%)	VS	EF	CH_4 (kg/an)	Emission CO_2 x 10^{-12} (t/year)
1	10	370.68	269.17	8.01	5.06	7.58	75.78	1894.54
2	10	333.9	216.61	8.24	5.85	8.76	87.56	2188.95
3	12	314.81	205.16	8.52	5.47	8.19	98.23	2455.68
4	12	322.16	205.34	9.56	5.83	8.72	104.65	2616.22
5	10	329.51	218.68	8.35	5.53	8.27	82.74	2068.42
6	12	315.52	198.20	10.51	5.85	8.76	105.10	2627.41
							554.05	13851.23

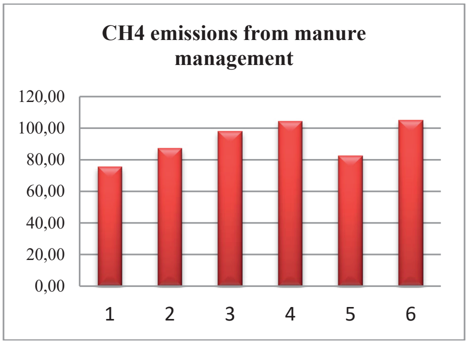

Figure 1. Methane emissions from manure management

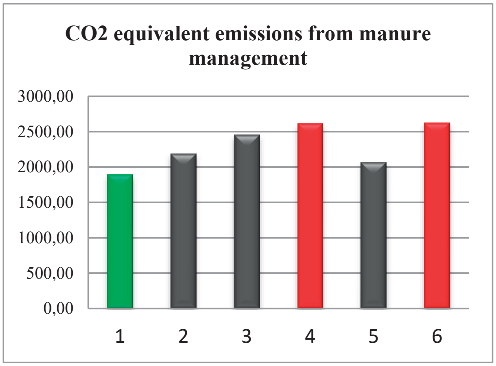

Figure 2. CO_2 equivalent from manure management

Methane and carbon dioxide equivalent emissions are the highest in variants 6 and 4 and the lowest in variant 1 with green fodder (75.78 kg CH_4/year, equivalent CO_2x10^{-12} 1.89 kg/year). Variant 2 with the highest amount of contaminated fodder used in the ration has determined an intermediate value, which is consistent with the research undertaken by several authors (Dhiman & Satter, 1997; Groff & Wu, 2005), which showed that the inclusion of contaminated maize in lactating cows' ration can improve animal production.

Experimental variant of ration no. 1 and no. 5, which contain a large amount of green mass, show that methane emissions from manure management decrease compared to ration variations in which animals receive more concentrates feed.

CONCLUSIONS

Together with the aspects of milk production, a number of measures are needed on the use of feed and feeding techniques that take into account the digestibility, quality and composition of the feed ration, which can reduce the methane generated during digestion.

The methane emission from enteric fermentation has the highest values for the variants 6 and 4, which contains rots (sunflower and soybean), maize, and wheat bran and the lowest emissions are recorded for the ration variant 1 which is rich in green fodder. In variant 2 with a reduced proportion of fibrous fodder a value of 1294 kg/year has been obtained. It is a middle value of CH_4 emissions from enteric fermentation.

Emission reductions can be made available to producers in the steer farming sector and the adoption of current best practices and technologies for the rearing and health of animals, feed rations can be a tool that would help the dragline sector reduce greenhouse gases.

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of greenhouse gases, expressed in tonnes of CO_2 equivalent”.

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