Greenhouse gas emissions from Pasture and Confinement Dairy Systems in Maritime Canada

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There are many ways to produce a litre of milk. Large, intensive, confinement dairy farm systems, which invest high amounts of fossil fuel to achieve high milk yield per cow, are rapidly becoming more prevalent in the Canadian dairy industry, replacing those employing pasture. This trend is associated with a shift from seasonal grazing to year- round feeding of silage in total mixed rations (TMR). Higher yield reduces CH_4 emission per L milk, thus confinement systems that use more grain and less methanogenic fibre are assumed more desirable compared with pasture systems. However, few data exist on GHG emission from grazing, lactating, dairy cows, and the environmental impact of this shift regarding total GHG emission has not been studied. A broad perspective is needed to evaluate dairy systems because of differences in fossil fuel use as well as emission of enteric CH_4, soil C, and N_2O.

We isolated first the effects of diets peculiar to system on CH_4 emission, either TMR or fresh forage at a vegetative stage cut from pasture under Management Intensive Grazing (MIG). During two consecutive summers, 2001 and 2002, 20 mid-lactation Holstein cows were cycled through two respiration chambers in three crossover studies. Pasture forage was supplemented with concentrate (containing 75% grain as well as protein, mineral and vitamin) twice daily at milking at the rate of 0.25% of milk yield. The TMR was balanced with enough concentrate to support 35 kg milk of based on the nutrient content of the ensiled mixed forage. Methane collected from chambers was analyzed using FTIR spectroscopy equipped with a long-path gas cell and MCT detector.

Milk yield averaged 31.3 kg d^{-1} and was not affected by diet. Similarly, methane emission was not affected by treatment either, averaging 383 g cow^{-1} day^{-1}, or 16.8 g CH_4 kg^{-1} milk. These effects are particularly interesting considering that cows fed the TMR consumed nearly 40% more concentrate (0.39 vs. 0.28 kg kg^{-1} milk).

In 2003, CH_4 production in cows was estimated using the SF_6 tracer technique, which measures oral emissions was compared with that obtained using respiration chambers, which measure whole body emissions. Statistically there was little difference, but whole body emissions tended to be higher.

In 2004 we employed the SF_6 method in a balanced design using 20 cows on-a commercial dairy farm to compare emissions of CH_4 emission from free- ranging cows grazing a MIG pasture or confined in loose housing and fed TMR. Gas was analysed using gas chromatography. MIG cows received about 9 kg TMR DM d^{-1} as their supplement. Energy and protein densities of pasture forage were consistently higher than those of the silage in the TMR. MIG cows gained more weight over the 11 weeks than those fed TMR, and the MIG system required 40% less concentrate (0.16 vs. 0.41 kg kg^{-1}). Average CH_4 emission was significantly higher from grazing cows compared with those in confinement (442 vs. 384 g cow^{-1} d^{-1}; 13.5 vs. 11.5 g kg^{-1} milk.

Lush pasture often contains a surfeit of ruminally degradable N that is related to higher excretion of urea in urine and could result in high N_2O emission. Emission of N_2O is perhaps of greater importance than that of CH4, therefore, in 2003, we conducted a crossover trial to examine the effects of dietary protein (CP) level, 11.6 vs 20.6 (dry matter basis) (28% of CP undegradable (estimated using SPARTAN ration balancing software)on enteric CH_4 emission and soil N_2O emission from urine affected patches on pasture. Ten cows and respiration chambers were used to measure CH_4 emission. Urine obtained by total collection from 2 cows on each treatment was applied to grass pasture (<15% legume by botanical separation), that had received no chemical N fertilization for 8 y previously, but, at times had carried a considerable legume component (25-40%). N_2O emissions from sward were monitored using 24 vented static chambers (60 cm diameter) replicated over treatments of no urine, and urine from cows on high or low protein diets. Chambers were deployed 2-4 x per week over the grazing season, using a protocol of 3 gas samples taken over 40 minutes. Samples were analyzed for N_2O by gas chromatography.

From O.26 to 0.61% of urinary N was emitted as N_2O during the 3-month period following early summer application of urine from cows fed either low or high protein diets, respectively. No carry-over effect was seen from urine applied the previous summer. Aggregated over the year, N_2O from urine patches represented approximately 1 to 3% of the total GHG impact of milk production. Results suggest that N_2O emission from MIG pasture, that had received no chemical N fertilizer, makes a small contribution to total GHG emission of a dairy farm.

Using predicted life-cycle fossil fuel consumption, we estimated system GHG emissions of 1.02 and 1.17 kg CO_2 equivalents kg^{-1} milk for MIG (pasture) and TMR (confinement) systems, respectively. We conclude that pasture- based milk production may not have higher GHG impact compared with that of high- grain confinement systems, at least at herd production levels around 9 to 10,000 kg cow^{-1}. Consequently GHG emission per unit of milk yield is a false indicator of progress towards reducing GHG emission from the sector. Feeding more grain to achieve higher milk yield is accompanied by hidden emissions of GHG.

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