Greenhouse gas emissions during the fermentation of sugarcane silages

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Introduction In recent years, agricultural systems have been presented as major source of greenhouse gas (GHG) emissions, mainly due to the use of fertilizers, deforestation and enteric fermentation from ruminants. In Brazil, according to the National Inventory of Greenhouse Gases Emissions (MCT, 2009) 71% of all methane came from the agriculture. Emissions of methane (CH_4) and nitrous oxide (N_2O) contribute considerably to the greenhouse effect, with potentials of global warming of 23 and 296 times higher than the carbon dioxide (CO_2) (IPCC, 2001). In Brazil, there is a lack of detailed information and research about the pollutant potential of industrial activities, energy and mainly agriculture. The last one is of fundamental importance due to the international role of Brazil as a food-producing power. Also, the pollutant potential of silage production is poorly understood in comparison with the quantitative importance of this food in animal production systems. The aim of this paper was to evaluate the GHG emission during the fermentation of sugarcane silages and the potential for mitigation using additives.

Materials and Methods The trial was carried out at the Centro de Pesquisa em Forragicultura (CPFOR) of Federal University of Paraná, in Curitiba, PR, Brazil. The sugarcane variety RB 72-454 was harvested at 32.8% of dry matter (DM) and the following treatments were applied: CONTROL – no additives; Chemical additive within LOW (4 g t^{-1}) or HIGH (8 g t^{-1}) dosages (wet basis), with five replicates for each treatment. The treated forage was ensiled in plastic buckets (20 L), equipped with a mobile apparatus for recovery and measurement of the volume of gas produced. The bulk density of the silos was 600 kg m^{-3}, and they were stored for 66 days. Using a pipeline and a collection chamber made of low density polyethylene, the total amount of gas of each silo was registered daily. On days 5, 33 and 61, samples were collected for determination of the concentration of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). For gas sampling, 20 mL polypropylene syringes with closure valve were used. After homogenization, gas samples were collected and syringes were kept in a styrofoam box with ice (below 10 ^{o}C) and were sent to Laboratory of Soils of Federal University of Rio Grande do Sul for analysis using Gas Chromatography (GC Shimadzu 14-A). Data was analyzed for a completely randomized design using PROC GLM of SAS.

Results and discussion No treatment effect was detected for any variable, probably due to the high coefficient of variation. A higher gas production has occurred during the first seven days of fermentation, and a strong influence of temperature over the gas production was noticed (Figure 1). The room temperature influences the metabolism of microbial population reflecting over gas production. However, the temperature has strong effect on the physical volume of the gases, which can lead to errors in analysis of results. The average daily gas production for each silo was 138.3 mL. The total amount of 2.08 L of gas was produced for each kg of DM ensiled. The gases were mainly composed by carbon dioxide (23054 ppmv – 99.9%) with low levels of methane (2 ppmv) and nitrous oxide (937 ppbv). Probably, the high concentration of CO_2 is related to the yeast metabolism, which converts sucrose to ethanol, producing 2 mols of CO_2 (McDonald et al., 1991).

A poor correlation (0.146) between volume of gas measured (mL) and disappearance of dry matter as gas (% of dry matter) was detected (Table 1). This sounds alarming once the traditional measuring of gases could be inaccurate considering as gases losses the volatile compounds lost during oven drying. The average GHG emission was 36.4 g of CO_2 eq per ton of forage (wet basis). This values are much lower than the estimates of GHG emission from feedlot cattle (5.6 kg CO_2 eq per kg of live weight gain) or dairy cattle (1.1 kg CO_2 eq per kg of milk) (Phetteplace et al., 2008). Although no statistical difference was observed due to the high coefficient of variation, the high dosage of additive showed a production of gases 7.5 times lower than control (27.5 vs 208.9 ml day^{-1} in control) and the emissions of GHG was reduced by 8 times when compared with untreated silage (7.0 vs 56.1 g CO_2 eq t^{-1} of forage for untreated silage).

Conclusion Carbon dioxide is the main gas produced during sugarcane ensiling process. The use of additives on silages can be an important strategy for GHG mitigation.

Reference

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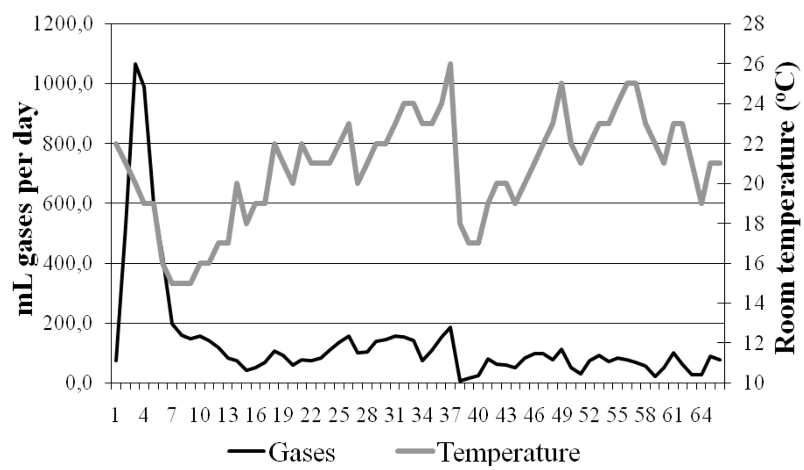

Figure 1 Gas production of sugarcane silages and room temperature during 66 days of storage.

Table 1. Greenhouse gas emissions during ensiling of sugarcane silage

Variable	Treatment[1]			*Mean*	CV (%)
	Control	Low	High		
Gas production, % of DM	6.7	6.2	9.1	7.3	34.5
Gas production, mL per day	208.9	178.4	27.5	138.3	214.8
GHG, g CO_2 eq t^{-1} forage	56.1	46.1	7.0	36.4	214.7

[1]Control, no additives; Low, 4 g of chemical additive per ton; High, 8 g of chemical additive per ton.