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Environmental impact assessment of milk production: is a simplified tool possible?

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Abstract

The aim of this study was to develop a simplified tool for estimating Climate Change (CC) associated to milk production at farm level that can be easily used by farmers. An accurate environmental impact assessment of milk production is the first step to select the best mitigation strategies to make milk production greener. Most studies in this field use Life Cycle Assessment (LCA) to estimate various environmental impacts of milk production at the farm level. LCA is a robust method, although time consuming. However, the current need of the sector is to start extensive estimation of environmental impact of milk production in dairy farms, at least for the Climate Change (CC) category, to set up a starting point for measuring future improvements. The study was performed on 54 dairy cattle farms located in Northern Italy. A complete LCA analysis was performed, and some performance data were recorded in the last 3 years. The latter were retrieved from the national fertility database managed by the National Breeders Association of Holstein, Brown, and Jersey (ANAFIBJ, Cremona, Italy) and consisted of production, management, and fertility data (i.e. pregnant cows at 120 d, and milk sold per Livestock Unit, LU), and genetic indices (i.e. Health and Economic Index - IES, predicted Methane Emission Index - pCH4). On average, the number of lactating cows in the selected farms was 232.2 (min 56, max 817), Fat and Protein Milk production (FPCM) per lactation was 9591±1357 kg. The inclusion of soybean meal, in the ration of lactating cows, was on average 10.7±5.28%. The CC impact was estimated starting from IPCC 2019 equations for modelling CH_4 and N_20 emissions related to the on-farm processes, while for off farm ones, data from databases were used (Agrifootprint and Ecoinvent). The EF 3.0 method was used for CC estimation. Average CC of the farms in the dataset was 2.00±0.31 kg CO_2 eq/kg FPCM. Subsequently, multivariate analyses were performed using R and SAS software using CC, farm characteristics and performance data. The Principal Component Analysis (PCA) was performed to find a multidimensional relation between variables.
With the aim to find an equation for estimating CC (CC_es) using few variables, easy to be collected at farm level, a linear model with stepwise selection was used. Starting from a collinearity test, variables with high VIF (Variance Inflation Factor) were excluded from the

dataset. Stepwise procedure (Ordinary Least Squares, OLS) was used to select the best parameters for CC_es. Variables selected were presence of biogas, percentage of soybean meal in the ration, IES and CH4 indexes, age at first calving, pregnant cows at 120 d, and milk sold per LU. Adjusted R^2 of the equation was 0.63. Validation of the equation was performed by randomly selecting 15 farms from the database 1,000 times to test the equation, and the average correlation coefficient between CC_es and CC was 0.77. From PCA, CC resulted inversely related with biogas presence, percentage of replacement animals on total LU and percentage of cows pregnant at 120 days after calving. The last two parameters are linked with an efficient farm management, characterized by a limited ratio between unproductive (heifers and open cows) and productive animals and by fertility efficiency. The mitigation effect of the presence of biogas was very high. The IES index also showed negative correlation with CC_es, On the other hand, while increasing percentage of soybean meal in the ration resulted an increased value of CC_es. Fertility efficiency parameters i.e. pregnant cows at 120 d, and milk sold per LU were inversely proportional to CC_es.