Geophysical Research Abstracts
Vol. 17, EGU2015-15009-1, 2015
EGU General Assembly 2015

Simulation with models of increasing complexity of CO_2 emissions and nitrogen mineralisation, after soil application of labelled pig slurry and maize stalks

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High amounts of nitrogen are available per unit area in regions with intensive livestock operations. In swine farms, pig slurries are frequently incorporated in the soil together with maize stalks. Simulation models may help to understand nitrogen dynamics associated with animal manure and crop residue decomposition in the soil, and to support the definition of best management practices.

The objective of this work was to test the ability of different models to simulate CO_2 emissions and nitrogen mineralisation during a laboratory incubation (under optimal soil water content and constant temperature) of maize stalks (ST) and pig slurry (PS).

A loam soil was amended with labelled (^{15}N) or unlabelled maize stalks and pig slurries, in the presence of ammonium sulphate (AS). These treatments were established: unfertilised soil; ST15 + AS + PS; ST + AS15 + PS; and ST + AS + PS15. During 180 days, we measured CO_2 emissions; microbial biomass C, N, and ^{15}N; and soil mineral N (SMN and SM-^{15}N). Three models of increasing complexity were calibrated using measured data. The models were two modifications of ICBM 2B/N (Kätterer and Andrén, 2001) and CN-SIM (Petersen et al., 2005).

The three models simulated rather accurately the emissions of CO_2 throughout the incubation period (Relative Root Mean Squared Error, RRMSE = 8-25). The simplest model (with one pool for ST and one for PS) strongly overestimated SMN immobilisation from day 3 to day 21, both in the treatments with AS15 and PS15 (RRMSE = 27-30%). The other two models represented rather well the dynamics of SMN in the soil (RRMSE = 21-25%), simulating a fast increase of nitrate concentration in the first days, and slower rates of nitrification thereafter. Worse performances were obtained with all models for the simulation of SM-15N in the treatment with ST15 (RRMSE = 64-104%): experimental data showed positive mineralization of stalk-derived N from the beginning of the incubation, while models strongly underestimated ST15 mineralisation until day 7. Due to model structure, trade-offs exist between a good simulation of CO_2 emissions and a good simulation of SMN. Therefore, simulation performances of the three models are a compromise between the errors in the simulation of C and N dynamics. Thus, some models (especially the simplest one), overestimated or underestimated SMN to match CO_2 measurements.

This preliminary work emphasised the importance of testing models with both C and N measurements. This reduced the risk of obtaining model parameters suitable for the simulation of N (or opposite C) dynamics that lead to unrealistic simulation of C (or N) decomposition. The use of ^{15}N-labelled materials will help to improve models for the simulation of added organic matter decomposition.

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