PREDICTING C AND N FATE FROM MIXTURE OF SUGARCANE STRAW AND ORGANIC FERTILIZERS. MECHANISTIC APPROACH BY MODELING

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INTRODUCTION

Carbon (C) budget and nitrogen (N) mineralization in mulch cropping systems depend on both residue and fertilizer inputs. Mixing organic fertilizer – N and straw - C seems to lead to interactive relations, controlled by mineral N contents for OF (Aita et al. 2012, Giacomini et al. 2015) and N diffusion between microbial biomass and C sources (Garnier et al. 2008) . However, predicting C and N fate when mixing different C and N sources is challenging, because it is necessary to better describe the mechanisms that drive the potential mineralization rates. The objective of our work was to study C and N mineralization from mixtures of plant residues and OF in soil, and to compare them with the mineralization of these OF applied alone.

MATERIAL AND METHODS

Acquisition of experimental data

An incubation experiment of soil samples (Nitisol from La Reunion) was conducted during 182 days at 28°C in a dark room (AFNOR, 2016). The C-CO_2 was measured at 14 dates and mineral N was measured at 9 dates. The treatments included organic materials with different physicochemical characteristics either incubated alone as pig slurry (PS), digested solid sewage sludge (DS) and sugarcane straw (S), or incubated as mixtures, namely pig slurry with sugarcane straw (PS-S) and digested solid sewage sludge with sugarcane straw (DS-S). The doses of organic or mineral inputs were calculated to provide non-limiting organic N for the mixtures, and non-limiting mineral N (KNO_3) for S treatment.

Modelling strategy

CANTIS is a mechanistic model simulating C and N transformations in soils (Garnier et al. 2003). CANTIS-simulated curves were fitted with a single set of parameters to the experimental data obtained with S, PS and DS treatments. The same set of parameters was used to predict the C-CO_2, N-NO_3^- and N-NH_4^+ kinetics from the mixtures (PS-S and DS-S). The difference between predicted and measured dynamics for the mixtures was considered as interactions. In CANTIS, the contact factor (K_{MZ}) is an empirical function that accounts for modifications of the rate of microbial colonization of C source and/or N source. Since N limitation was previously attributed to the contact area between soil and residues (Garnier et al. 2008, Iqbal et al. 2014), we calibrated K_{MZ} to account for the interactions. The predictions were evaluated using Nash-Sutcliffe model efficiency index (*Ef*).

RESULTS AND DISCUSSION

Calibrating CANTIS model enabled a good prediction of all measured variables (CO_2, NO_3^- and NH_4^+) for the treatments S, PS and DS and for the control soil, as all the Nash-Sutcliffe model efficiency indexes were positive. However, CANTIS model overestimated the CO_2 measured in both mixture treatments, PS-S and DS-S. This suggests a N limitation occurring when mixing different C and N sources, that CANTIS model does not consider using the parameters calibrated for a single organic source. Considerable improvement of the prediction of C and N kinetics was obtained by fixing K_{MZ} to 60 and 130, for PS-S_{corr} and DS-S_{corr} respectively, compared to PS-S and DS-S, respectively (fig. 1). The higher value of K_{MZ} for DS-S treatment, indicates that the N uptake was less efficient, compared to PS-S. This was probably due to the lower N diffusion and consequently, the lower N accessibility from the sewage sludge. We hypothesized that the distance between N and C was responsible for the antagonistic interaction, that reduces C colonization by decomposers and leads to a lower CO_2 release, than in case of pure additivity (K_{MZ} = 0).

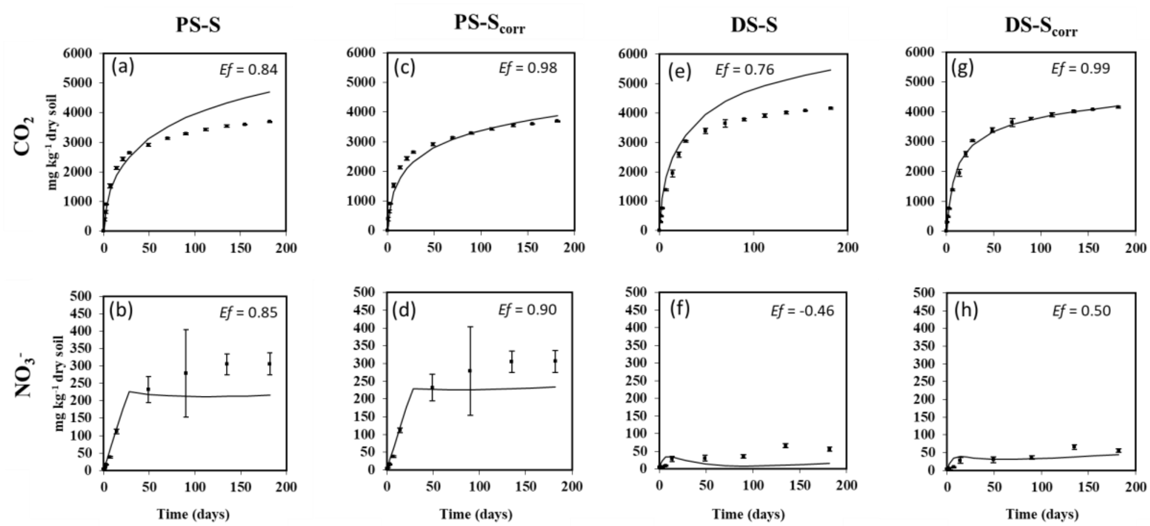

Figure 1 : CANTIS-simulated (lines) and observed (dots, standard deviation) data for C and N mineralization kinetics during incubation of mixtures of organic materials in control soil with (PS-S) pig slurry and sugarcane straw (a, b), (PS-S$_{corr}$) pig slurry and sugarcane straw with modified contact factor K_{MZ} (c, d), (DS-S) sewage sludge and straw (e, f) and (DS-S$_{corr}$) sewage sludge and straw with modified contact factor K_{MZ} (g, h), and their corresponding Nash-Sutcliffe efficiency indices (Ef).

CONCLUSION

The transformations of C and N from different organic sources in mixture have been accurately simulated with CANTIS model, by including and optimizing a function that reflects the accessibility of N. Thus, it is necessary to better describe and integrate the chemical and physical variability that characterizes the organic fertilizers, which determines the rate of their accessibility.

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