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A numerical model for microbially mediated soil aggregate formation considering the effect of crop residue quality

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It is crucial to understand what influences the dynamics of soil aggregates, because soil organic matter (SOM) stabilized inside aggregates is the fraction of SOM that is most susceptible to anthropogenic activity. Yet, there is a lack of numerical process models that include the dynamics of aggregate formation and breakdown and to date, no model represents the important connection between microbial carbon use efficiency (CUE) and aggregate formation. Here, we introduce a model of microbially mediated aggregate formation, which includes litter-stoichiometry and -quality dependent CUE and simulates soil aggregate formation facilitated by the microbial excretion of binding substances. The model is evaluated against measured data of microbial biomass, SOM content and intra-aggregate SOM from a long term bare-fallow experiment in a tropical sandy soil, which was subject to plant litter addition of different qualities. The benefit of simulating aggregates in a model of SOM dynamics is assessed by comparing it against a version that does not, both being separately calibrated to the same dataset. Our results show that the developed model can effectively represent the microbial growth response that follows litter addition and the formation as well as the delayed breakdown of soil aggregates, after the microbial growth peaked. As shown by a higher modelling efficiency and a lower Akaike information criterion, the model version that includes aggregate formation outperforms the one that does not in the simulation of total organic carbon, total N and for the decomposition of litter. Additionally, it can represent the temporal dynamics of C stored in the silt and clay fraction. Yet, while the model could capture the temporal dynamic of aggregates as a result of litter quality, the amount of C in aggregates in the control treatment without litter addition was underestimated. Our results suggest that aggregate formation is an important process that could be included into SOM models to improve the simulation of both aggregated and non-aggregate pools. However, the underestimation of aggregate C in the control could be a hint, that abiotic aggregate formation may be a relevant factor, especially in low input systems, and may also need to be included.