Effects of Improved Parameterization of STICS Model to Simulate C-N Dynamics in a Long Term Field Experiment with Organic Amendments

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Introduction

- Organic amendments (manure, compost…) are applied to improve soil fertility in the long term (soil organic matter, nitrogen supply to crops…)
- Long-term experiments necessary to validate soil-crop models further used to predict the effects of scenarios of organic amendment application
- Although STICS is one of the most popular soil-crop model, none study have focused on organic amendment application
- The standard version of STICS is currently using a simple formalism (Nicolardot et al., 2001) to simulate organic amendment decomposition
- The biological meaning of some parameters should be considered, especially the assimilation yield of decomposed organic matter by the zymogenous microbial biomass which is known to be inferior to 60 % for (Lee and Schmidt, 2014; Spohn et al., 2016)

Objective : To assess STICS performances when simulating C and N fluxes in a long-term experiment depending on the parameterization of the organic amendment decomposition submodel

## Study site : the QualiAgro long-term experiment

- Deep decarbonated luvisol
- Grain maize – winter wheat rotation
- 10 Treatments: 5 amendments modalities (4 amendments + control (**CT**)) × 2 mineral N fertilization modalities (optimal N+ / minimal N-)
- Four organic amendments applied every two years at the dose of 4 t C/ha : farmyard manure (**FYM**), green wastes and sludge co-compost (**GWS**), green and food-wastes co-compost (**BIO**) and a compost of mechanically separated organic fractions from residual waste (**MSW**)
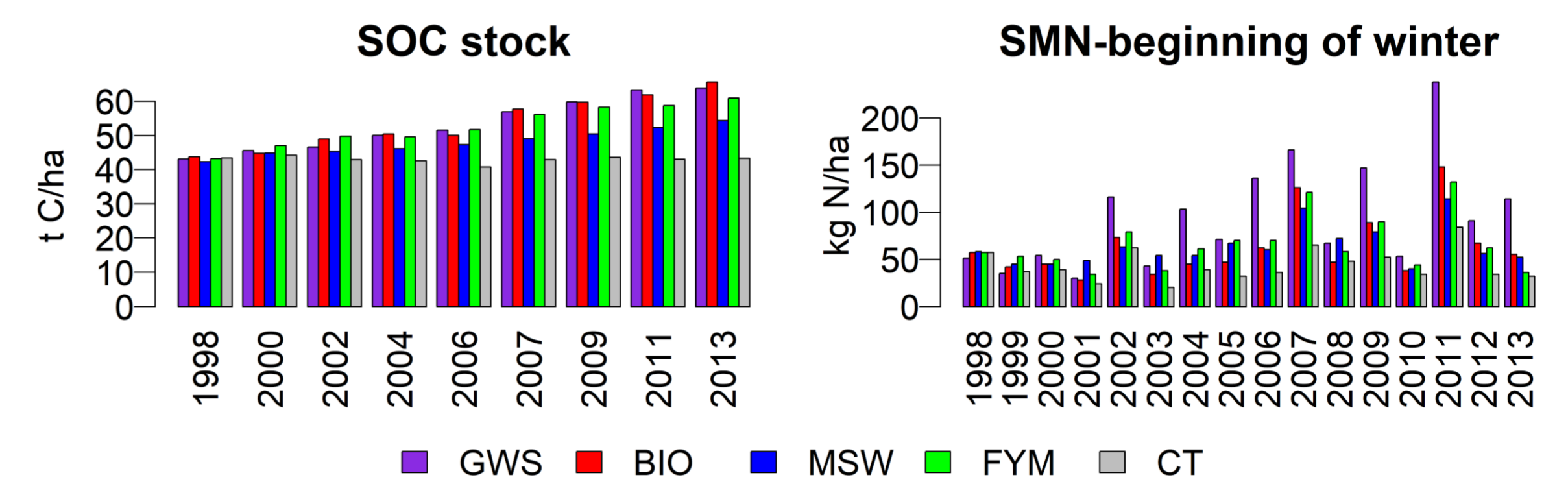
Examples of C and N dynamics observed in the QualiAgro experiment: soil organic carbon (SOC) stock and soil mineral nitrogen (SMN) at the beginning of winter

Methods

- Comparison of three modelling strategies:
  1) Standard version of STICS with the simple decomposition model and microbial biomass assimilation yield (**Y**) bound to 100 %
  2) Standard version of STICS with the simple decomposition model and **Y** bound to 60 %
  3) Modified version of STICS with a complexified decomposition submodel and **Y** bound to 60 %
- Models paramaterization with the Generalized Likelihood Uncertainty Estimation (GLUE) method (2000 simulations) and seven control variables: aboveground biomass, plant N uptake, grain yield, grain protein content, soil water content, soil mineral N content, soil C stock
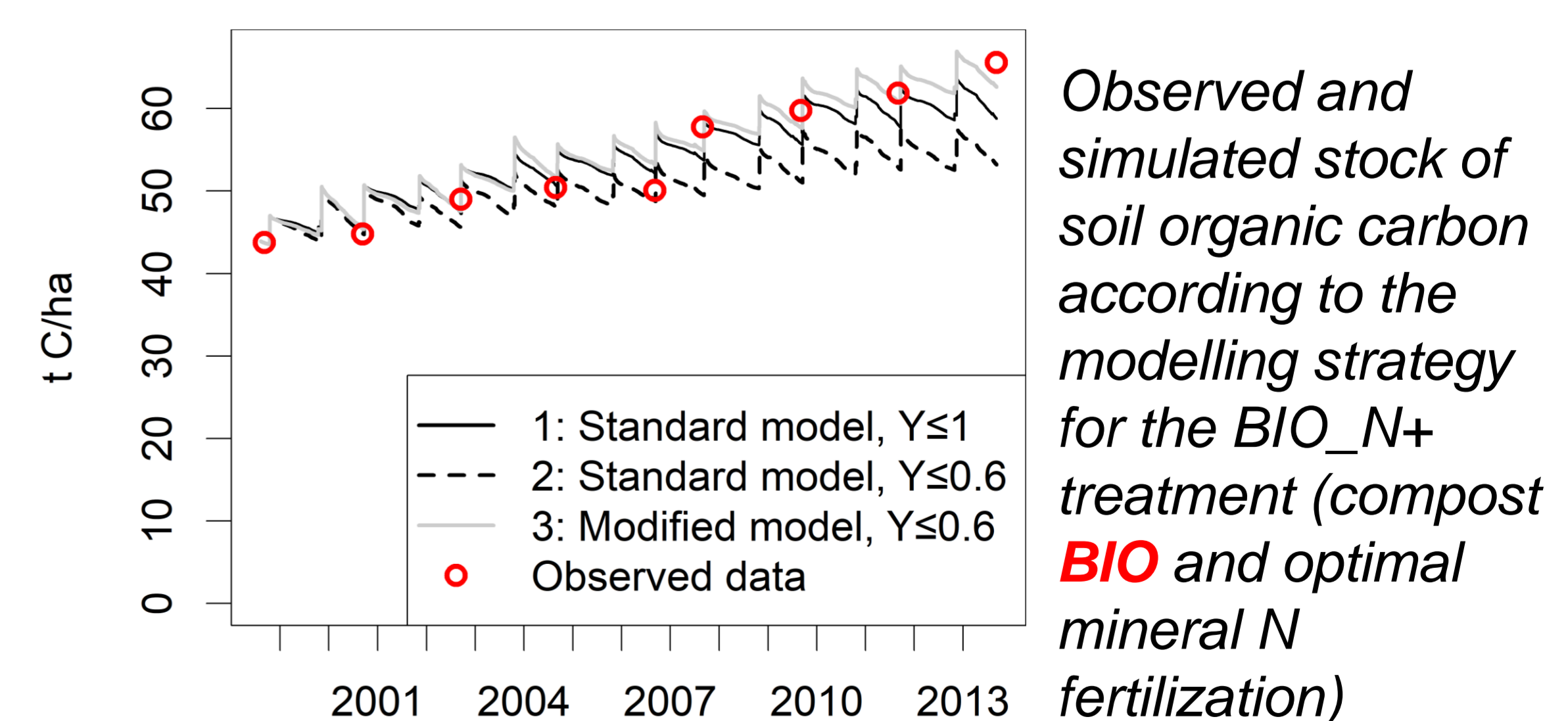

Standard version of STICS

Modified version of STICS

* The stable pool do not decompose at all
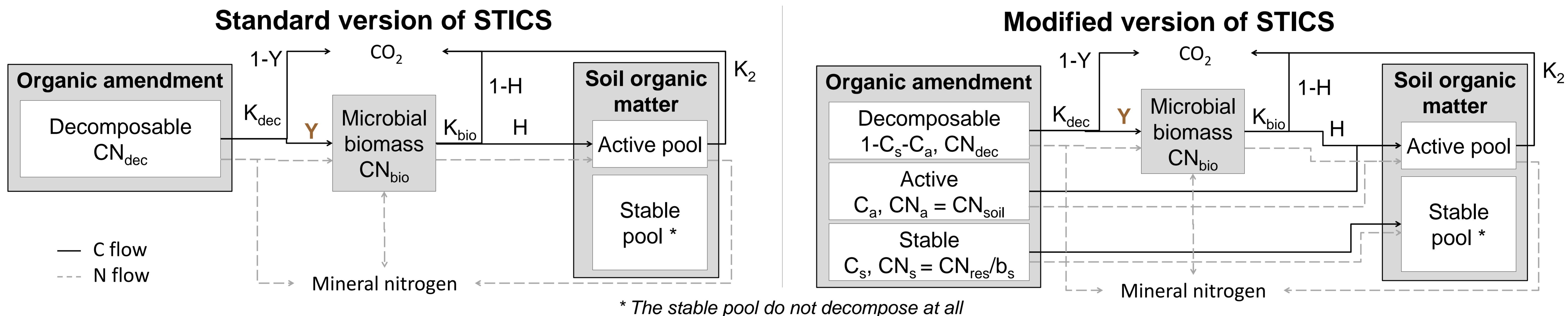
Results

1) Standard version of STICS without considering a biological meaning of Y (Y≤100%) :
   - Modelling performances in the organic treatments were acceptable, similar to control treatments without organic amendments whatever the considered variable, and similar to other studies without organic amendment (Coucheney et al., 2015)
   - Carbon storage was however slightly underestimated at the end of the experiment
   - Both microbial biomass assimilation yield (**Y**) and humification yield (H) equal to 100 % were calibrated with the GLUE method
2) When the biological limit of the microbial biomass assimilation yield was forced (**Y**<60%), the model performances strongly decreased
3) Modified version of STICS :
   - Allocating C and N of amendments in the active and stable pools of soil organic matter allowed to restore the model performances
   - Improvement of the modelling performance of soil organic carbon in comparison to the standard version
   - Stable carbon in organic amendments represented from 20 % (**MSW**) to 43 % (**BIO**)
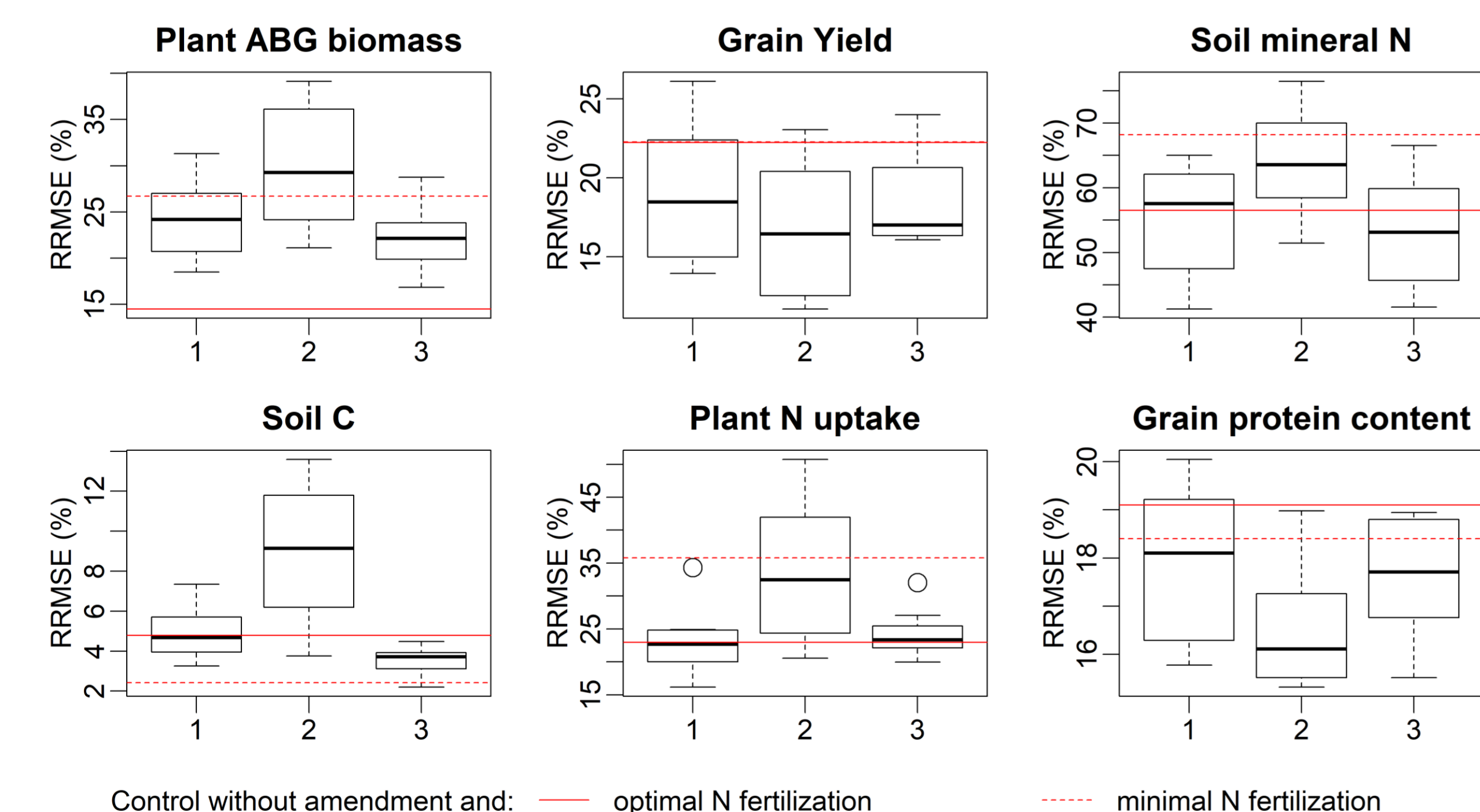
Relative Root Mean Squared Error between observed and simulated values with STICS, for (1) the standard version, (2) the standard version with Y<0.6, and (3) the modified version of STICS. Each boxplot represents the dispersion of RRMSE values of the eight treatments with organic amendments.

*Observed and simulated stock of soil organic carbon according to the modelling strategy for the BIO_N+ treatment (compost **BIO** and optimal mineral N fertilization)*

Conclusion

- While preserving a biological meaning of parameters, a complexified model with allocation of C and N of amendments in active and stable pools of soil organic matter is needed
- Need to test the modified version of STICS on other sites and to develop laboratory methods to predict the decomposition parameters of organic amendments

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