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Introduction

Accurate modelling of soil organic carbon (SOC) dynamics on the long-term is required to better predict the environmental impacts of cropping systems and notably their potential to sequester atmospheric CO_2 into SOC that can play an important role in greenhouse gas mitigation and soil fertility. To date, a limited number of studies have been conducted to evaluate the ability of STICS to simulate soil organic nitrogen dynamics (*e.g.* Constantin et al. 2012; Autret et al. 2019; Yin et al. 2020). There is therefore a need to assess the ability of STICS to simulate SOC dynamics and to compare its modelling performances with models validated for various situations.

Methods

A research version of STICS (Autret et al., 2019) was used to simulate SOC dynamics (0 to 20-30 cm) in long-term field experiments that were either under bare fallow (Farina et al. 2019) or cultivated conditions (Table 1).

Table 1. Description of the selected long-term experiments.

Experiment	Code	Rotation	Duration (years)	Initial SOC stock (t C ha^{-1})	Final SOC stock (t C ha^{-1})
Askov-B3/B4	Ask3/4	Bare fallow	29	52.1/47.7	36.4/33.0
Grignon	Grign	Bare fallow	48	41.7	25.4
Kursk	Kursk	Bare fallow	36	100.3	79.4
Rothamsted	Roth	Bare fallow	49	71.7	28.6
Ultuna	Ult	Bare fallow	51	42.5	26.9
Versailles	Vers	Bare fallow	79	65.5	22.7
La Cage-Co-B1/B2	Cage-Co1/2	Pea-Wheat-Rapeseed	16	43.4/37.5	44.7/38.8
La Cage-Li-B1/B2	Cage-Li1/2	Pea-Wheat-Rapeseed	16	49.5/37.6	48.3/40.0
Feucherolles-Min	Feu-Min	Wheat-Grain Maize	15	43.4	43.3
Feucherolles-T0	Feu-T0	Wheat-Grain Maize	15	42.7	39.0
Kerbernez-A	Kerb-A	Silage Maize	26	81.7	57.8

The model performances were compared with those of the annual time-step carbon model AMG v2, which had been previously validated for various pedoclimatic conditions and cropping systems (Clivot et al. 2019).

Results and discussion

Results show that STICS could predict satisfactorily final C stocks after a long-term monitoring of SOC in bare fallow and cultivated systems (Fig. 1). The diversity of experiments suggests that STICS was able to simulate well both decomposition and mineralization derived from native soil organic matter and from fresh organic residues that are incorporated into humified organic matter.

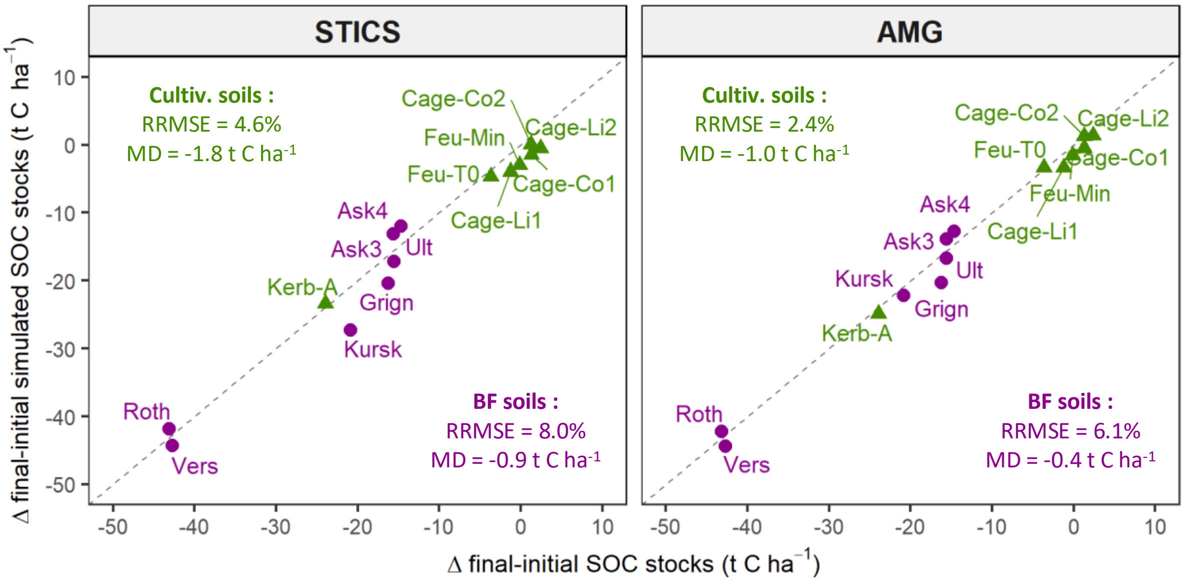

Figure 1. Differences between final and initial observed SOC stocks *vs* simulated with STICS and AMG models for bare fallow (BF) and cultivated soils in long-term experiments.
RRMSE = relative root mean square error and MD = mean difference for final SOC stocks.

The performances of STICS in simulating SOC are comparable to those of AMG model (mean RRMSE of 6.3% and 4.3% for final SOC stocks simulated with STICS and AMG, respectively), for which C inputs into soil require measured crop yields to be calculated, while STICS provides the advantage of simulating crop growth and residues returned to the soil.

Further studies will be needed to assess the model ability to simulate SOC dynamics in other systems such as grasslands or cropping systems including perennial species.

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