Modeling with stics the effects of no-tillage vs. tillage in cropping systems under contrasting pedoclimatic conditions

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Introduction

STICS has been widely employed in many agro-environmental contexts, especially in conventional tillage and temperate climate. But, few studies have evaluated STICS in no tillage and tropical conditions. Furthermore, these studies are based on ancient versions of the model, where the biological processes affecting the mulch of crop residues are not described. We hypothesized that i) the balances of water, C and N at a short, medium and long-term are more affected by the crop residues behavior than the soil structure when comparing the effects of no-tillage vs. tillage; ii) the residues behavior greatly depends on interactions occurring within the pedo-techno-climate conditions system. We tested here the ability of the new version of STICS (v8.3.1) to simulate cropping systems based on no-tillage and with a permanent cover of a mulch of plant residues under contrasting temperate and tropical climates.

Materials and Methods

Four mid-term field experiments were selected under temperate and tropical conditions, located in France (*Boigneville*), Denmark (*Foulum*), Argentina (*Pergamino*) and Brazil (*Rio Verde*) (Table 1). See Constantin et al., (2010), Hansen et al., (2010), Restovich et al., (2012), and Maltas et al., (2007) for more details of the sites. STICS was evaluated by comparing the model predictions with the observed values. We tested: i) aboveground biomass and N; ii) yield and N; water balance: soil water content (SWC) and water leaching; and iii) N balance: soil mineral N content (SMN), and NO_3 leaching. The comparison was made both in a reset mode and in a continuous simulation mode for the sites of *Boigneville*, *Foulum* and *Pergamino*, and only in a reset mode in *Rio Verde*. The performance of the model was evaluated calculating the mean difference (MD), the root mean square error (RMSE), and the model efficiency (EF).

Results and Discussion

We found some problems regarding the varieties selected for maize and soybean in *Pergamino* and *Rio Verde* sites, and for local varieties of winter wheat, spring oat, winter barley and spring pea in *Foulum*, which required the calibration of some plant parameters. In *Rio Verde*, it was also necessary to calibrate some general parameters of the model to adapt them to tropical conditions, such as a fast recycling of the labile N fraction in tropical soils, very high rainfall, and a strong nitrate retention (Sierra et al., 2003). After calibration, the results of simulation by using STICS v8.3.1 were good for most of the selected output variables in a continuous run (0.4<EF<0.8). The main exception was SWC in *Pergamino* and SMN in *Boigneville*, whose results were better in the reset mode than in the continuous run. Results in the *Rio Verde* site were also good (0.5<EF<0.9). It was possible to directly assess the ability of the new version for providing the mulch behavior of the crop residues only at *Rio Verde*, as opposed the other sites, where observed data are lacking. Yet, at the latter sites, the same set of parameters has provided realistic mulch behaviors.

Table 1. General characteristic of the study sites. CC= catch crops, NT= no-tillage, CT= conventional tillage, BS= bare fallow soil

	Climate	Duration	Crop rotation	Treatments
Boigneville (France)	Oceanic temperate (604 mm, 11.5°C)	1991-2006	w. wheat – s. barley – s. pea + CC	NT vs. CT + mulch + ≠ CC vs. BS
Foulum (Denmark)	Oceanic temperate (626 mm, 7.3 °C)	2002-2012	w. wheat – s. barley – pea – s. oats + CC	NT vs. CT + mulch vs. no mulch + CC
Pergamino (Argentina)	Temperate humid (971 mm, 16.5°C)	2005-2013	soybean-maize + CC	NT + mulch + ≠ CC vs. BS
Rio Verde (Brazil)	Humid tropical (1600 mm, 22°C)	2003-2005	soybean-maize + CC	NT + mulch + ≠ CC vs. BS

Conclusions

This *in silico* experiment leads us to revise the classification of parameters (local vs. global) while it permits to verify the reliability of our hypothesis. In a near future, STICS ability will be indirectly evaluated through the comparison between observed and simulated soil content of the water, carbon and nitrogen (mineral and organic).

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