Soil organic carbon dynamics in soybean-based cropping systems in the Brazilian Cerrados

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Introduction

Soybean (*Glycine max*) cultivation has steadily expanded in the Cerrados region for the last 40 years[1, 2] and a larger increase is expected[3]. The Brazilian savanna, or Cerrados, covers over 200 million ha. The clearance and cultivation of native land has a direct effect on the C cycle of the Cerrado ecosystem and especially on the C stored in the soil (SOC). Although a decline of SOC is expected under conventional tillage (CT) of soybean monocropping, no conclusive statements can yet be made regarding the ultimate change in SOC. Conversely, the introduction of best management practices, that include no till (NT) and cover crops, are expected to help restore the SOC content closed to pre-clearing levels.
The objective of this study is to get a better understanding of SOC dynamics in soybean-based cropping systems, under different agricultural practices, by using a summary model on soil carbon[4].

Material and methods

- *Two long-term field experiments* were selected at two centres of the Brazilian Agricultural Research Corporation (EMBRAPA). These sites met the following criteria: an area with native land adjacent to cropping systems, long-term field experiments (>10 years) and near complete records of past and current crop and land management (Table 1).

- SOC dynamics were evaluated using the *summary model* [4] that comprises: a SOC and N (SOM) module, a SOIL module, and a CROP module. The SOM module (Figure 1) considers three C pools; the rates of decomposition follow an exponential decay.

- Model projections were compared to long-term experimental data[5,6].

Table 1: Historical crop sequences in conventional (CT) and no tillage (NT) treatments of each experimental site: Embrapa Cerrados (Planaltina, DF) and Embrapa Beef Cattle (Campo Grande, Matto Grosso do Sul).

Year	Embrapa Cerrados		Embrapa Beef Cattle	
	CT	NT	CT	NT
1991			-	-
91/92	S	S	-	-
1992			-	-
92/93	M	M	-	-
1993			-	-
93/94	S	S	-	-
1994			-	-
94/95	M	M	S	S
1995				PM
95/96	S	S	S	S
1996				PM
96/97	M	M	S	S
1997				PM
97/98	S	S	S	S
1998				PM
98/99	S	S	S	S
1999				PM
99/00	M	M	S	S
2000				PM
00/01	S	S	S	S
2001				SG
01/02	PM	PM	S	S
2002				SG
02/03	S	S	S	S
2003				SG
03/04	S	S	S	S
2004				SG

Notes: S = Soybean; M = Maize (*Zea mays*); PM = Pearl Millet (*Pennisetum glaucum*); SG = Sorghum (*Sorghum bicolor*)

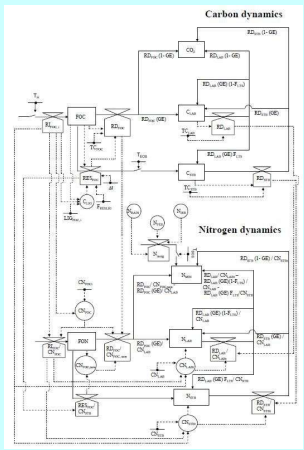

Figure 1: Relational diagram of the SOM module: soil organic carbon and nitrogen pools and their dynamics.

Results and discussion

Embrapa Cerrados (Figure 2, picture 1):

- The initial simulated SOC stock of 80.9 Mg C ha^{-1} agreed well with the value of 81 Mg C ha^{-1} reported for native land[6].

- The model projected a C decrease for all treatments with 8% and 9% SOC losses in CT systems after 11 years of cultivation (S4CTF1 and S4CTF2, respectively) and 5% in NT systems (S4NTF1 and S4NTF2). The reported SOC stock depletion of 4 Mg C ha^{-1} after eleven years of cultivation[6] was close to the projected loss of 6.5 Mg C ha^{-1}. Conversely, the projected loss of 4 Mg C ha^{-1} did not agree with the increase of 3 Mg C ha^{-1} of SOC stocks in of NT systems, pointing at the need for further model evaluation and understanding of the soil C system.

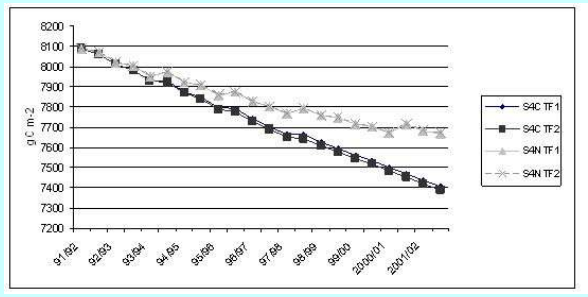

Figure 2: Projected SOC stocks (g C m^{-2}) in 0-40 cm soil depth, after eleven years of cultivation of the 4 treatments of the long-term experiment at Embrapa Cerrados. S4CT = Conventional Tillage systems with different fertilization rates (F1 and F2); S4NT = No Tillage systems with different fertilization rates (F1 and F2)

Embrapa Beef Cattle (Figure 3, picture 3)

- Projected SOC stocks of 51 Mg C ha^{-1} agreed with reported[5] SOC stock of 54 Mg C ha^{-1} in the first 20 cm soil layer.

- After eleven years of cultivation, SOC stocks were 46.3 and 47.4 Mg C ha^{-1} in CT and NT systems[5]. Here, the model performed satisfactorily by projecting 48 and 50 Mg C ha^{-1} in the first 20 cm soil layer after 11 years of the experiment.

Conclusions

- Reduced soil tillage and the greater intensification of cultivation have shown a trend of reducing SOC losses after 11 years of cultivation. Carbon sequestration rates of NT systems, with the simulated data and CT system as a reference sites, respectively.

- The degree of complexity of the summary model is considered adequate for exploratory studies. The three SOC pools approach allowed for the analysis of differences between possible effects of different tillage practices on C dynamics

- additional long-term experimental data are needed for a full scale evaluation of the summary model.

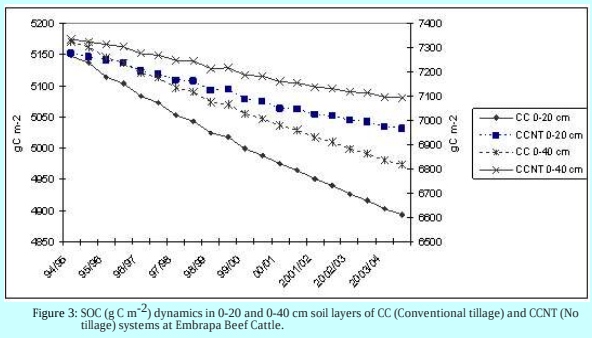

Figure 3: SOC (g C m^{-2}) dynamics in 0-20 and 0-40 cm soil layers of CC (Conventional tillage) and CCNT (No tillage) systems at Embrapa Beef Cattle.

Picture 1. Experimental unit at Embrapa Cerrados (Planaltina , DF)

Picture 2. Seeding in soybean fields in Rondonopolis (MT)

Picture 3. Experimental unit at Embrapa Beef Cattle (Campo Grande, MS)

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