SHORT-TERM EVOLUTION OF C-CO_2 IN CONVENTIONAL AND NO TILL SYSTEM FOR A BRAZILIAN OXISOL: EFFECT OF TILLAGE AND RAINFALL

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Introduction

The soil organic carbon (SOC) content depends strongly on soil management and especially the level and quality of organic restitution to the soil. Changes in soil management can alter SOC content. A substantial increase in the SOC content in the 10 cm topsoil layer in no-tillage soils compared with soils under natural vegetation and long-term conventional tillage (CT) (Séguy et al. 2003) can occur due to high crop-residue input and lack of soil disturbance. Enhancing carbon sequestration in soil is an important means to reduce net emissions of carbon dioxide (CO_2) to the atmosphere. The soil organic carbon (SOC) pool is the net result of carbon (C) input in the form of crop residue and biomass, and output including CO_2 flux and other losses (Duiker, 2000).

Using a CT system affects C dynamics, aggregation and soil structure, and interaction with cropping system which in return affects C sequestration in soil.

C sequestration in soils depends on three factors: (i) turnover time, and (ii) physical or chemical protection against microorganisms, and (iii) soil erosion. Accounting for C and nitrogen (N) dynamics in the active C and N pools is crucial to understand how management of production systems can pe improved to sustain long term soil productivity especially in warm climates (Salinas Garcia, 97). However, this higher stock may generate higher emissions of CO_2. We propose here some elements of a method that aims at following the main stages of the agricultural cycle and we present our first results.

Material and methods

The experiment was carried out during the 2002-2003 cycle in Goiânia, Goiás, Brazil. The measures were conducted on a dark red latosol (pH around 5.9). The climate of the area is tropical with average annual temperature of 22.5 °C and total precipitation of 1500 mm. The experimental design consisted of 2 treatments (no tillage (NT) and conventionnal) on Rice fields. Conventional system called here offset (OFF) consists in using a disk (0-15 cm depth) to prepare the soil before seeding.

The CO_2 emissions were monitored in two special circumstances: after plowing (offset disk, 10 to 15 cm depth) and after a strong rain using a manual system based on static chamber techniques and LI-COR 6262. This IRGA was connected to a closed chamber (volume = 6L/ surface = 0.08 m^2) permitting exchanges between the chamber and the analyser. $[CO_2]_{chamber}$ were measured in a minimum of five discrete samples taken at regular intervals (1 minute) during the deployment period. The greater number and frequency of $[CO_2]_{chamber}$ measurements also facilitates using shorter deployment period in case you have an automatic analyser. CO_2 emissions from all the chambers were measured during 5-minutes periods in 6 replicates for each treatment.

Results

We first measured C stocks in this soil after 5 years of NT or OFF. As there was no significant difference in bulk density between the 2 systems (1.2 to 1.35 in 0-40 cm), we only considered the concentration of organic C in each soil (%C). The measurements were realized with a CN analyser

(LECO CN-2000, CENA- Piracicaba , Brazil). % C had also been measured when starting the experiment 5 years ago assuming an homogeneous %C in soil (at least on 0-10 cm).

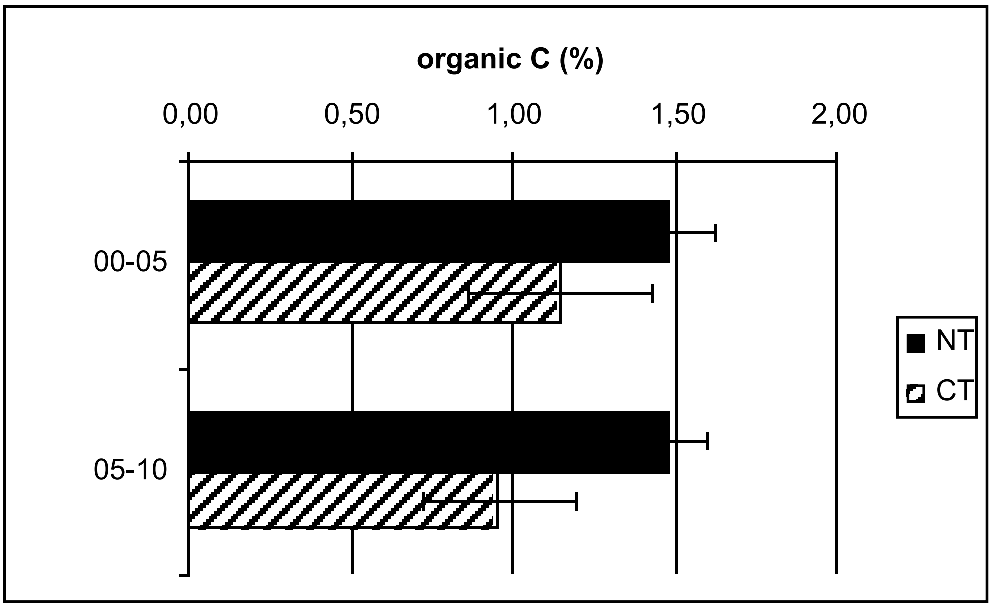

Figure 1: % carbon after 5 years of experimentation

We observed an increase in the C stock in NT systems. This increase was commonly observed under both temperate and tropical conditions (De Sá et al., 2001). The C balance results from the long term sequestration and the short term losses. Consequently, the time scale used to calculate C balance is decisive and comparing different ages of NT fields or measuring C losses during special events of the agricultural cycle. Soil respiration is commonly estimated as the flux of CO_2 emitted from the soil surface. It represents the sum of CO_2 produced by root respiration and heterotrophic decomposition and plant litter.

a) after tillage:

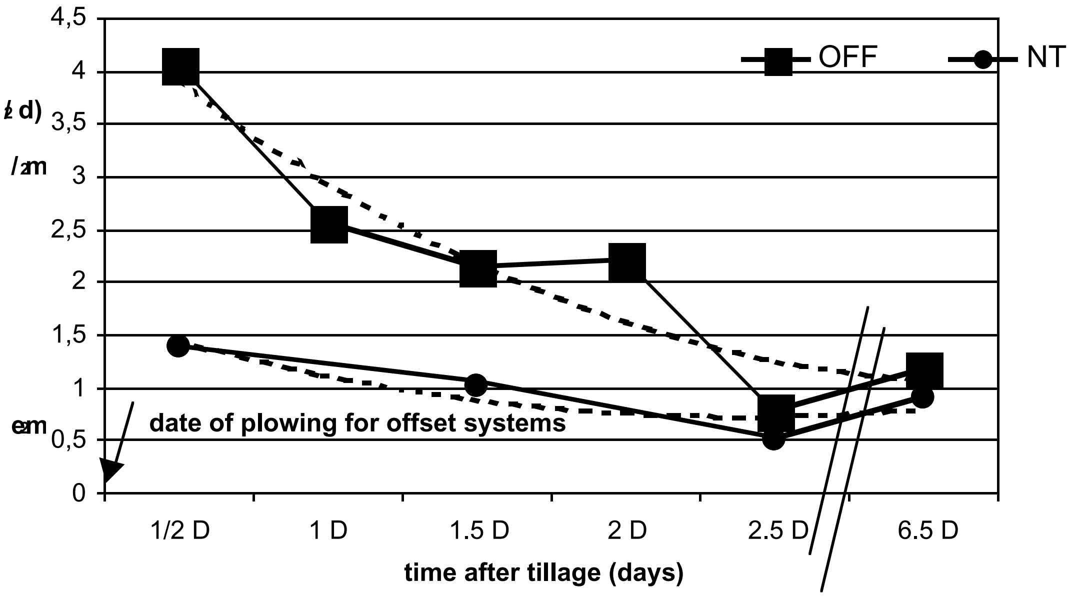

Figure 2: effect of tillage on CO_2 emissions, comparison between offset ad no tillage systems

In NT systems, there was no change in CO_2 emission. In OFF systems we showed a strong increase in CO_2 emissions. This increase tended to disappear 2.5 days after tillage. Reicosky (1997) showed an important effect on the first day after tillage.

b) after rain (30 mm)

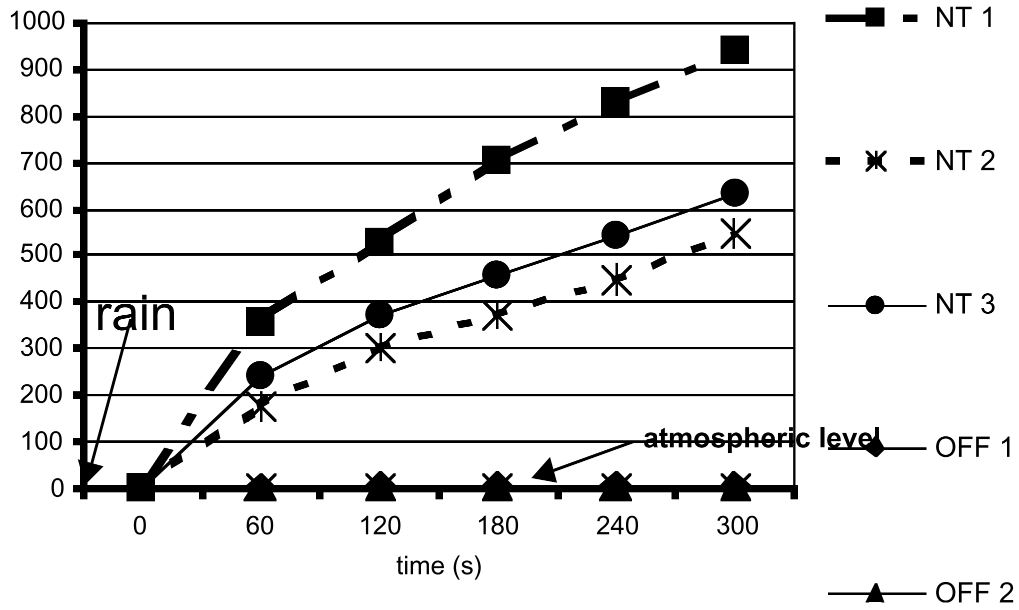

Figure 3: effect of a strong rain (30 mm) on CO_2 emissions

We observe here that in case of strong rain (here 30 mm during 1 hour) OFF does not emit CO_2 at all, at least during the period following the rain. On the contrary, NT had a continuous and stable emission. The volumetric moisture was 46.9% and 46, 5% for NT and OFF systems respectively.

Discussion and conclusion

It seems that the differences between the two cultivation techniques are due to physical, biological and chemical differences induced by the technique. The reasons for an increase in CO_2 emissions after tillage are to be found in physical parameters of each type of soil: tillage breaks the aggregates which liberates the protected organic matter, then chemical consequences can be invoked such as the degradation by air of the aggregates. The differences observed after a strong rain can be explained by the physical impact of tillage. The porosity in the 0-10 cm layer is different between tilled and no-tilled. We can explain the special consequence of tillage on CO_2 fluxes by the fact that most respiration activity occurs in the top 25 cm.

The preliminary results of this study show that it is decisive to follow the CO_2 emissions all the cycle long and that the impact of a technique is very complex for it may affect most physical, biological and chemical properties of a soil. The positive conclusions concerning the balance of carbon sequestration positive for no tillage systems have to be completed by measurements of N_2O and CH_4 emissions in the frame of the global comprehension of the effect of agriculture on global change. The whole study (not presented here) will take into account this aspect and include measures of N_2O and CH_4 fluxes from soils as well as N mineral content, temperature, moisture,…

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