Carbon balance under intensive cropping systems

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COMPARATIVE experiments of intensive cropping systems show that mulch-based cropping systems are able to sequester carbon by i/ recycling a sizeable biomass quantity into the soil and ii/ slow down mineralization, as compared to conventional tillage cropping systems.

Maïze after oat at ABC experimental station (Brazil).

Maïze on *Desmodium uncinatum* at Andranomanelatra (Madagascar).

Material and Methods

Experiments were carried out in tropical and subtropical regions, in Brazil and Madagascar.

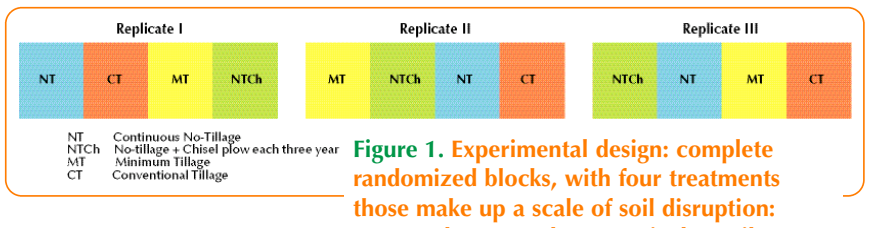


Figure 1. Experimental design: complete randomized blocks, with four treatments those make up a scale of soil disruption: NT, NTCh, MT, and CT. Tropical Brazil, Ponta Grosa (Parana), ABC experimental station.

In each experiment the compared treatments are cropping systems. In the No-Tillage systems (NT), the soil is permanently covered either by the crop residues or by an auxiliary forage crop. In the conventional tillage systems (CT), the residues are buried by seasonal ploughing. Intermediate treatments comprise superficial minimum tillage (MT) and soil disrupting with a Chisel (NtCh). Some experiments do not have a CT treatment, but include a fallow control.

Results

The Soil Organic Carbon (SOC) stock is higher under NT conditions, and varies with time, showing continuous transformation

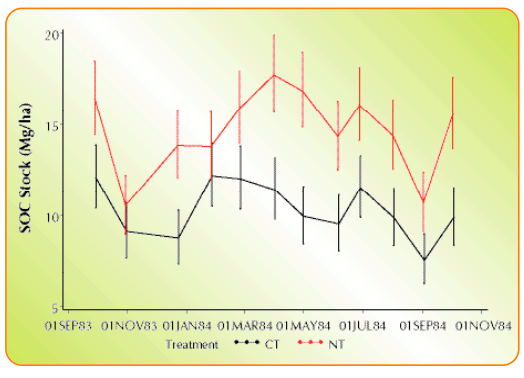
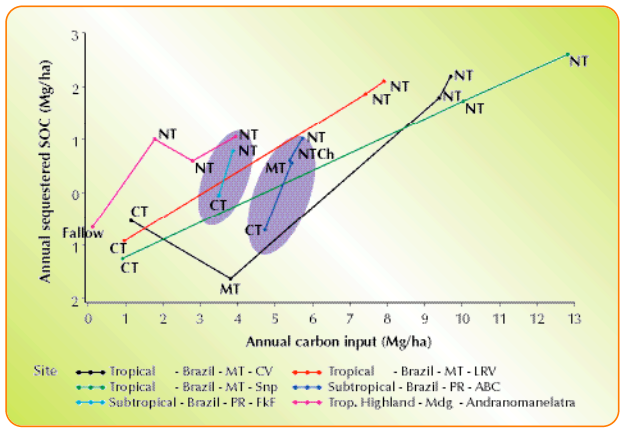


Figure 2. These monthly SOC measurements were made 15 years after the beginning of the experiment, on aggregates more than 53 µm in size, in the 0-10 cm layer. They show considerable seasonal variations of the SOC. These variations suggest a continuous flow and mineralization of an unstable form of organic carbon. However, analyses on smaller aggregates show that a stable fraction of C is consistently higher in NT treatments.

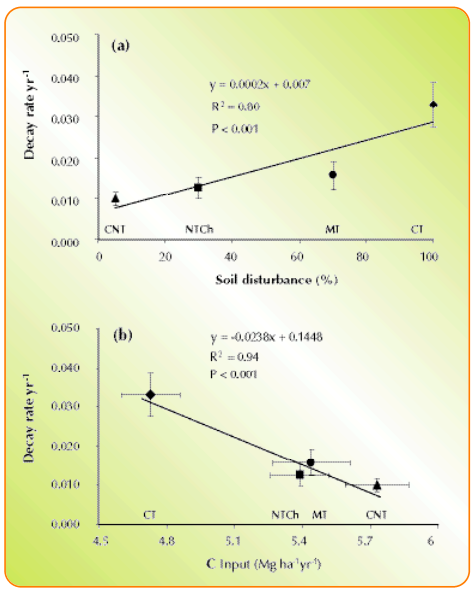
The net SOC annual sequestration is also higher in NT treatments, not only because of their higher C input

Figure 3. The no-tillage (NT) treatments with permanent cover input more C to the soil, and have a better carbon balance than the conventional tillage (CT) treatments: this is the general trend. However, in FkF and ABC locations of Brazil, while the CT and NT treatments have nearly the same carbon input, the NT treatments display a considerably better carbon balance. The explanation has then to be found in a slower mineralization under the NT cropping systems.



Soil organic carbon (SOC) mineralization speeds up with soil disturbance and slows down with soil protection

The slower mineralization of NT cropping systems is illustrated with the help of a carbon balance model, based on two assumptions: i/ of the carbon of crop residues leaved after harvest, a known fraction k_1 adds to the Soil Organic Carbon (SOC) and ii/ a first order differential equation is supposed to govern the decomposition of this SOC, considered as a single compartment. This SOC then depletes exponentially at the yearly mineralization rate k_2; k_2 is estimated from the available data of each treatment.



Figures 4a and 4b show the estimated mineralization rate as a function of the soil disturbance index, and as a function of C input. The mineralization rates are significantly different from one treatment to another, and the relationships suggest that lower soil disturbance and greater quantity of protective biomass are responsible for the lower mineralization rate of the Soil Organic Carbon under no-tillage intensive cropping systems.

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