Embrapa Cerrados · CIRAD

SOIL CARBON SEQUESTRATION AND MULCH-BASED CROPPING IN THE CERRADO REGION OF BRAZIL

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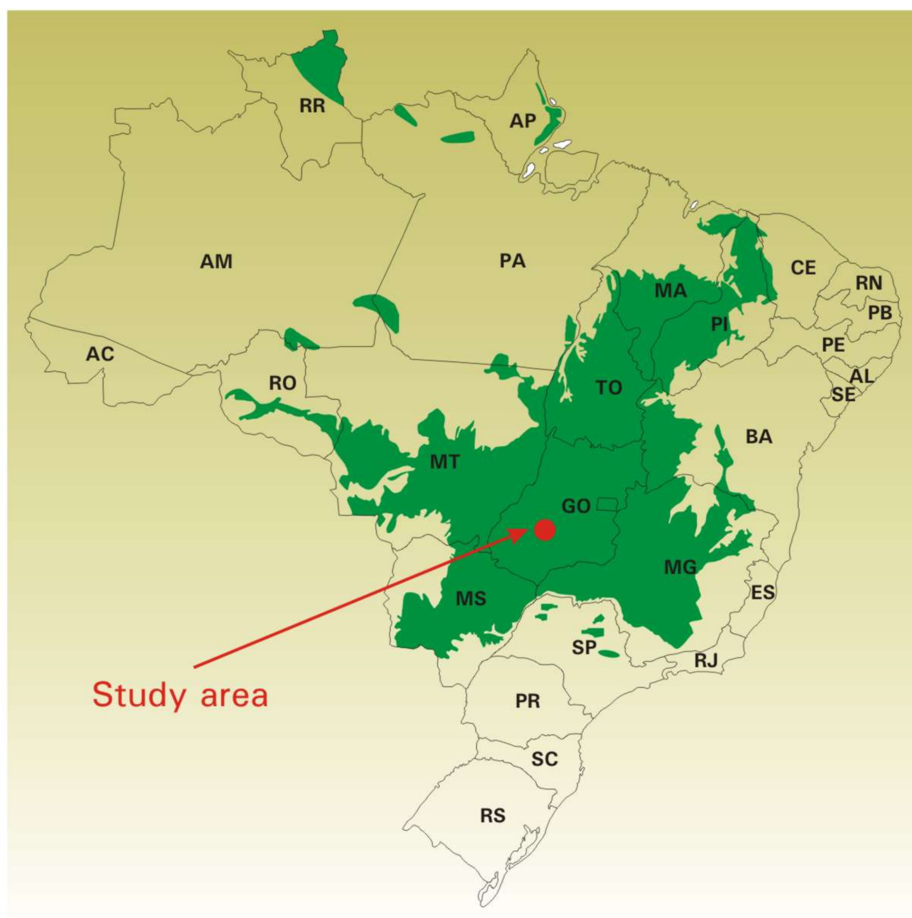
AIM

To assess the soil C sequestration potential of cropping systems with direct seeding into a mulch of plant residues (Direct seeding Mulch-based Cropping -DMC- systems) in the Cerrado region of Brazil.

BACKGROUND

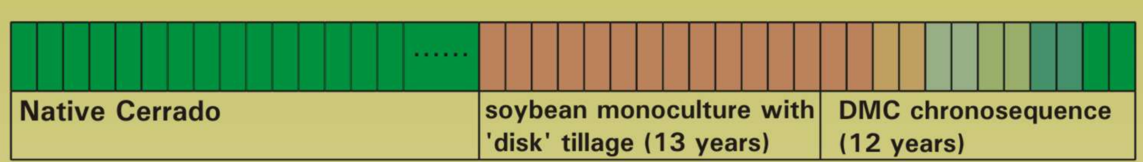


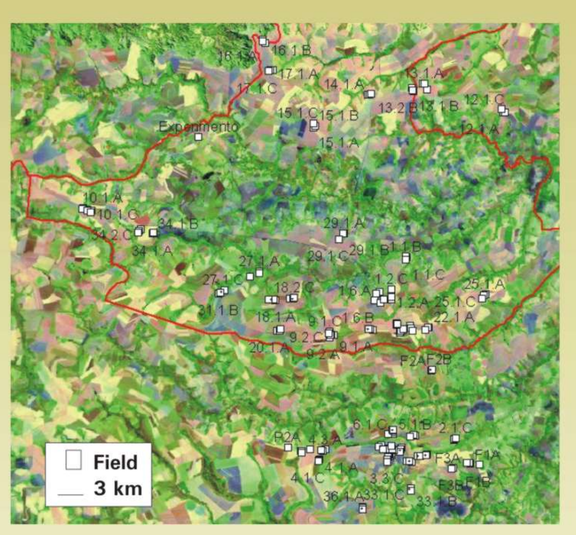
- Cerrados: tropical savannah of central Brazil
- Cerrados occupy approximately 23 % of the national territory
- Since the 1970s intense agricultural expansion: about 30 % of the native vegetation have been replaced by agricultural cropland or pasture
- No-till or direct seeding mulch-based cropping (DMC) systems have largely been adopted over the last 10 to 15 years: today over 4 million ha are cultivated using DMC practices
- Soil erosion is the major drive behind the development and adoption of DMC
- DMC systems represent a potential for soil organic carbon (SOC) sequestration by:
  - increasing C inputs to the soil
  - reducing C losses due to soil erosion
  - decreasing decomposition rates of SOC as a result of reduced mechanical soil disturbance.

MATERIAL AND METHODS

Study area and field sampling

Chronosequence of 45 fields of 0 to 12 years under continuous DMC.





The study area:
- municipals of Rio Verde (17° 47'S, 51° 55' W) and Montividiu (17° 24'S, 51° 14' W) in the Goiás state, on a plateau in the centre of the Cerrado region.

Climate:
- humid tropical with dry season
- mean annual rainfall: 1,600 mm, dry season from May till September
- mean minimum and maximum temperature: 17 and 27°C.

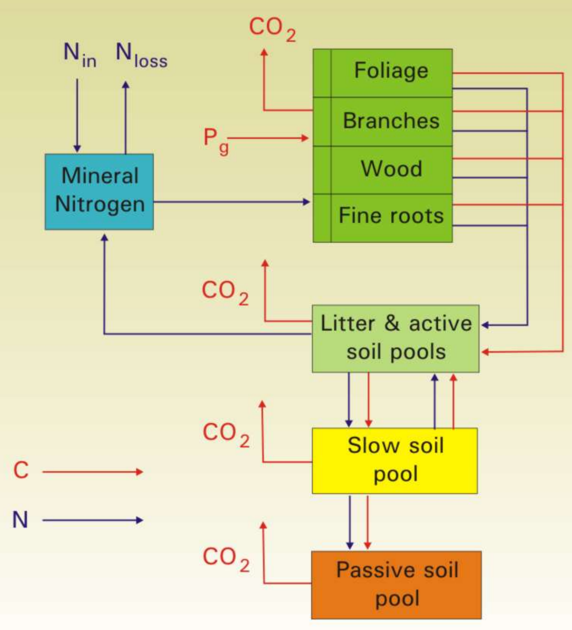
Soils:
- Geri-Gibbsic Ferralsols

DMC:
- no-tillage with a cover crop (millet, sorghum or maize) following the main crop (soybean or maize).

Measurements:
- soil samples: 0-5, 5-10 and 10-20 cm surface soil layers
- organic C and total N by dry combustion in a CHN Perkin-Elmer elemental analyser
- bulk density with volumetric steel ring
- soil particle-size analyses using the pipette method.

Simulation modelling

G'DAY: Generic Decomposition and Yield (Comins and McMurtrie 1993)
- Linked plant-soil model that incorporates the CENTURY organic matter decomposition submodel (Parton et al. 1993)
- Simulates changes in soil C and N with agricultural management.



Model parameterisation
- Non-site specific parameters from earlier G'DAY model testing (Commins and McMurtrie 1993; Halliday et al. 2003)
- 'Equilibrium' simulations under native savannah vegetation to initialise model pools of organic soil C and N.
- Simulated crop yields based on data recorded on farmer's fields.
- Fraction of total plant production allocated belowground based on crop-specific average values for root production obtained from the literature.
- Decomposition rates of soil C pools (active, slow and passive) were decreased with 25% to account for soil depth effects (0-40 cm).
- Tillage effects were simulated by:
  - transferring 80% above-ground crop residue into the soil
  - increasing decomposition rates of the soil C pools with 20% in the month after the tillage operation.

RESULTS

Soil C and N in surface soil

Experimental results

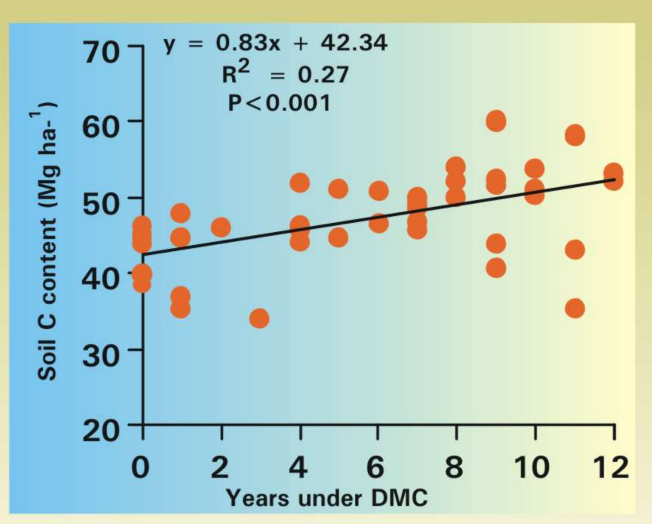


Figure 1. Soil organic C contents in surface soils (0-20 cm) in a DMC chronosequence in the Cerrado

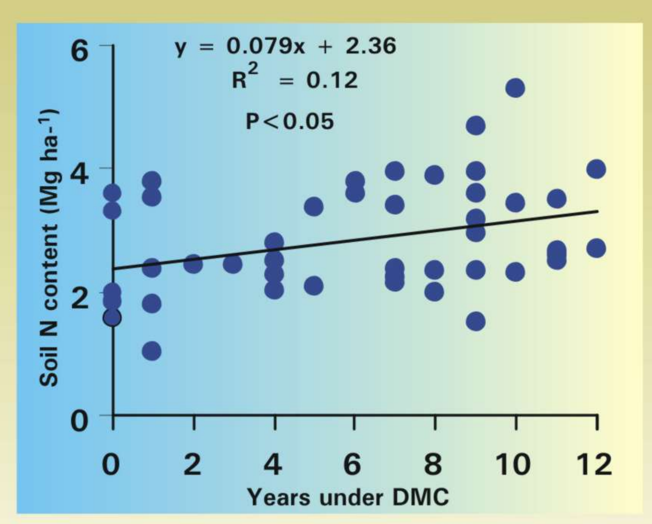
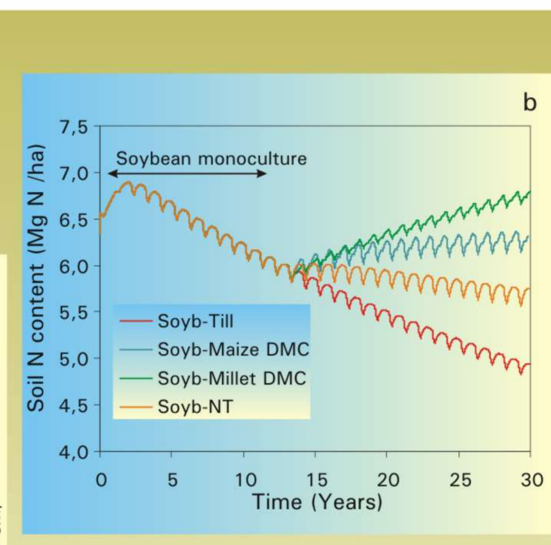


Figure 2. Soil total N contents in surface soils (0-20 cm) in a DMC chronosequence in the Cerrado region of

- SOC in surface soils (0-20 cm) are related to clay+silt content and years under DMC (76 % of variation accounted for)
- Average increase in SOC contents (0-20 cm, corrected for bulk density effects) is 0.83 Mg/ha/yr
- Total soil N contents (0-20 cm) increased on average with 79 kg/ha/yr
- No significant ($P > 0.1$) change in soil C:N along the chronosequence.

Model simulations

- Conventional soybean monocropping resulted in C losses of about 40% after 30 years
- DMC systems have the highest potential to sequester C and N following 13 years of monocropping
- Simulated effects of no-tillage on soil C sequestration were quite substantial
- Gains in soil C under DMC are attributed to a higher NPP caused by greater cropping frequency, and less removal of NPP as harvest products
- Root production and turnover is considered to be an important determinant of soil C storage (Balesdent and Balabane 1996).



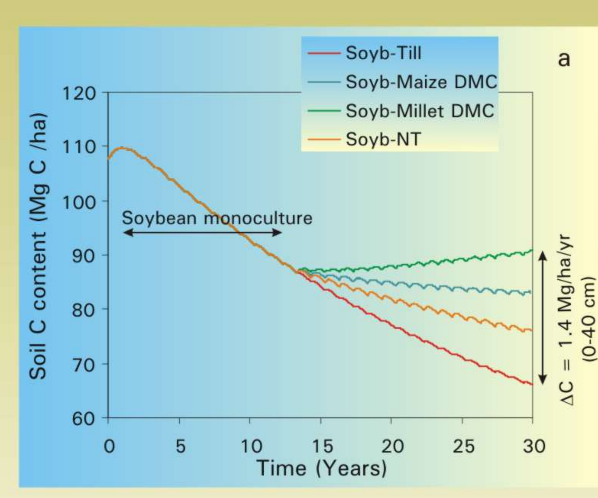


Figure 3. Modelled changes in soil organic C (a) and soil total N (b) contents in the 0-40 cm soil layer of a typical clayey soil (15 % silt, 70 % clay) for different scenarios of land-use after 13 years of conventional soybean monocropping. Time 0 represents steady state conditions under native savannah vegetation.

CONCLUSIONS

- DMC systems have potential for conservation of SOC in the tropical Cerrado region of Brazil.
- This is attributed to high crop residue input and the lack of soil disturbance.
- Gains in SOC are sustained by gains in soil total N, as results of increase N input or reduced N losses under DMC.
- Actual SOC sequestration rate under DMC (0-20 cm) is estimated at 0.83 Mg/ha/yr.
- At the scale of the Cerrados region: SOC sequestration with DMC is roughly estimated at 3.3 Tg/yr, which is equivalent to assimilation of 12.2 Tg CO_2 /yr.

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