Carbon balance and sequestration in no-till soils under intensive cropping systems in tropical agroecozones

João Carlos de Moraes Sá, Lucien Séguy and Francis Forest
Experimental Sites in the worldwide

- Cameroon
- Laos
- Thailand
- Vietnam
- Cambodia
- Brazil
- Madagascar
Methodology

No plowing, no tillage

Soil protected all year round

As high as possible production of biomass

Association/rotation of plants to bring...

Complementary functions for soil health
Concept of intensive cropping system

The meaning of the intensive cropping system comprise in to “close the window” between the rainy season (wet summer) and the dry season (dry winter) using cover crops associated with cash crops to maintain the soil surface permanent covered.
“The challenge in the tropics is the management of the crop residues decomposition rate to maintain the soil covered all year long”
Example: Campo Verde - MT, Brazil
Oxisol, Red Dark Latosol, Sand-Clay

26/03/2005
Annual C input = 9.7 Mg ha⁻¹ (21.6 Mg ha⁻¹ of Crop Residues)
Example of Soybean/Corn + Brachiaria + beef cattle rotation
Soybean harvest (3.5 to 4.0 tons of DM) - February

Corn and Brachiaria planting - February

Corn harvest (7.0 tons of DM) - June

Grazing June, July and August

40 days after harvest (root system > 50 cm)

October/November (Regrow)

December = 5.5 tons of Brachiaria DM

Soil permanent covered
“In tropical areas the challenge with cropping systems is to adjust cash crops and cover crops that can be profitable and compensate the high decomposition rates of the crop residues.”
Distribution of the decomposition products of the crop residues in the SOM pools

- **CO₂**
- 0.736 ton
  - 25° SL
  - Ponta Grossa Southern BR
- Input of 1.0 ton of crop residues
- Cerrado Sinop-MT 0.863
  - 14° SL
- Cerrado (PvLt) 0.847
  - 16° SL

Soil organic matter pool's
- 0.044
  - Live organism
- 0.06
  - No humic substances
- 0.16
  - Humic Substances

Stable (0.22 ton)

Source: Sá et al. 2001; 2007
Crop residues (Brachiaria *decumbens*) decomposition during the corn development
Rio Verde, 880 m ASL, Latitude ≈ 16° S, 2003-04, Oxisol (65% of clay)

![Graph](image)

- 8658 kg ha⁻¹ DM = 3896 kg ha⁻¹ C
- 79.94% lost in 117 days
- 58.26 kg day⁻¹ of DM
- 1910 kg ha⁻¹ DM = 860 kg ha⁻¹ C

Planting (19/10/03)
Flowering
Physiological Maturation
Harvest (16/02/04)

Source: Sá, et al, 2004
<table>
<thead>
<tr>
<th></th>
<th>1st yr</th>
<th></th>
<th>2nd yr</th>
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<th>3rd yr</th>
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<tbody>
<tr>
<td>Rainy season</td>
<td>Dry Season</td>
<td>Rainy season</td>
<td>Dry Season</td>
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<tr>
<td>OCT</td>
<td>NOV</td>
<td>DEC</td>
<td>JAN</td>
<td>FEB</td>
<td>MAR</td>
</tr>
<tr>
<td></td>
<td>1710 mm</td>
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<td>1718 mm</td>
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<table>
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<tr>
<th>Scv₁</th>
<th>Soybean</th>
<th>Fallow</th>
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<tbody>
<tr>
<td>Scv₂</td>
<td>Soybean</td>
<td>African Millet</td>
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<tr>
<td>Scv₃</td>
<td>Soybean</td>
<td>E. coracana + Crt</td>
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<tr>
<td>Scv₄</td>
<td>Soybean</td>
<td>Sorghum + Brachiaria</td>
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<td>Corn + Brachiaria</td>
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<td>Sorghum + Brachiaria</td>
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</tbody>
</table>

- **Soybean**
- **African Millet**
- **E. coracana + Crt**
- **Sorghum + Brachiaria**
- **Corn + Brachiaria**
- **Cover crop (Brachiaria)**

- **Sowing**
- **Harvest**
**SOC balance for 0- to 20-cm depth for experimental sites**

<table>
<thead>
<tr>
<th>Site</th>
<th>Cropping System/Till.</th>
<th>SOC Measured $t_1$</th>
<th>SOC Measured $t_2$</th>
<th>C input Cumulative</th>
<th>C input Annual</th>
<th>SOC Sequestration rates Mg ha$^{-1}$ yr$^{-1}$</th>
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<tr>
<td>CV</td>
<td>CT-S</td>
<td>18.12</td>
<td>17.04</td>
<td>2.29</td>
<td>1.15</td>
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<td>MT-S/Mlt</td>
<td>23.66</td>
<td>20.41</td>
<td>7.62</td>
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<td></td>
<td>NT-S/Els+Crt</td>
<td>28.47</td>
<td>32.05</td>
<td>18.78</td>
<td>9.39</td>
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<td></td>
<td>NT-S/Sgh+Brq</td>
<td>30.66</td>
<td>35.03</td>
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<td>LRV</td>
<td>CT-S</td>
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<td>43.70</td>
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<td>NT-S/Sgh+Brq</td>
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<td>68.80</td>
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<td>1.73</td>
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<td>NT-S/Tifton</td>
<td>43.02</td>
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<td>Adrom.</td>
<td>Fallow</td>
<td>47.37</td>
<td>41.40</td>
<td>1.08</td>
<td>0.12</td>
<td>-0.66</td>
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<td>Madag.</td>
<td>NT-M/S</td>
<td>47.37</td>
<td>56.38</td>
<td>16.05</td>
<td>1.78</td>
<td>1.00</td>
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<tr>
<td></td>
<td>NT-M+SD</td>
<td>47.37</td>
<td>52.69</td>
<td>25.08</td>
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<td>NT-S/GB+KK</td>
<td>47.37</td>
<td>56.81</td>
<td>35.50</td>
<td>3.94</td>
<td>1.05</td>
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Distribution of C in the particle size fraction in the profile under three crop rotations with cotton as the main crop (Campo Verde-MT, Brazil, 16° SL)

- **CT-C/Fw** (Cotton / Fallow)
- **MT-C/Mlt** (Cotton / African millet)
- **NT-C/Sgh+Bq** (Cotton / Shorghum + Brachiaria)
SOC stock affected by tillage and associated with cropping system
It follows that 14.7% of each additional Mg C input per hectare is sequestered as SOC.
Scenario 1 – Potential of C-sequestration based in average rate

Average rate of C-Sequestration
0.5 Mg ha\(^{-1}\) yr\(^{-1}\)
(Bernoux et al. 2006; Bayer et al., 2006; Cerri et al., 2007)
Scenario 2

Increase 15% with intensive cropping system
C sequestration average = 2.04 (Average among CV, LRV and Snp)
Scenario 3

Increase 20% with intensive cropping system in Cerrado region
C sequestration average = 2.04 (Average among CV, LRV and Snp)
Increase 25% with intensive cropping system in Cerrado region
C sequestration average = 2.04 (Average among CV, LRV and Snp) and 15% in Southern with C seq. at 1.0 ton ha⁻¹ year
Conclusions

In tropical areas is essential the management of the soil organic matter through adoption of intensive cropping systems to reach the sustainability of the farm business.

For those areas the C input to reach the equilibrium is close to 7.4 Mg C ha\(^{-1}\) yr\(^{-1}\). The farmers have to introduce the systemic approach to choice the cropping system and always try to “close the window” between wet and dry season because it is the way to enhance SOC sequestration and sustainability.
Conclusions

The challenge is to convince the farmers to adopt these system in large scale.

Four points to convince the farmers:

1. Reduction of costs
2. Reduction of the risks with weather impact (Drought)
3. Increase the yield of the main cash crop and the profitability of the whole system
4. Making extra money with C-sequestration and giving a good contribution to the environment.