Soil C sequestration for sustainable food production and climate change mitigation

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Soil carbon (C) sequestration & climate change mitigation

“Carbon” accumulated as black-colored “soil organic matter”

Dark-colored soils have higher concentration of carbon

Andosol (Japan) profile ~ 1m
In cropland, C in “biomass” does not change in longer time-scale. Increase in SOC means decrease in atmospheric CO$_2$ $\rightarrow$ sink of CO$_2$. $\Rightarrow$ Mitigation

For increasing SOC:
Increase C input or decrease decomposition rate.
Difference between soil C sequestration and other GHGs mitigation

<table>
<thead>
<tr>
<th>Soil C sequestration</th>
<th>CH4 and N2O mitigation</th>
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<tbody>
<tr>
<td>Positive effect on soil fertility</td>
<td>Emission reduction</td>
</tr>
<tr>
<td>➔ contribute to food security</td>
<td></td>
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<tr>
<td>Not only emission reduction. Possible to be “sink”</td>
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Positive correlation between soil C and crop yield

Figure 4. Relationship between winter wheat yields and values of organic C content in topsoil under different tillage systems during the period 2002 to 2009. CT – conventional tillage; NT – no tillage; MTS – minimum tillage + straw; NTM – no tillage + mulch

Mikanova et al. (2012)
Global Carbon cycle (IPCC AR5, 2013)

Atmosphere:
- $829 \pm 10 \text{ Pg}$
- $(P=10^{15} \text{ g})$

Vegetation:
- $450$ to $650 \text{ Pg}$

Soils:
- $1500$ to $2400 \text{ Pg}$
The 4 per 1000 initiative

- Launched in 2015 @ Paris COP 21
- Increase of 0.4% of total terrestrial SOC annually can offset annual increase in atmospheric CO2
- Climate change mitigation & sustainable agricultural production
- Over 280 partners (countries, NGOs etc.)

- Scientific & Technical Committee (STC)
- 14 scientist from the world
- Give technical advice
Criticisms

• Slogan (soil C as win-win strategy) is welcome for all, but criticisms on 0.4% target exists

1. Trade-off with other GHGs
2. Too ambitious target
3. Equilibrium and non-permanency
1. Trade-off:
need to evaluate total Global Warming Potential (GWP)

\[ \text{Soil C increase} \quad (\text{CO}_2 \text{ decrease}) \]

\[ \text{CH}_4 \quad \text{and N}_2\text{O} \quad \text{increase} \]

Combination with other mitigation option
\[ \text{e.g. Paddy water management to offset this} \]
2. Too ambitious target

- 0.4% per year (slope) is not feasible quantitatively: estimates are too high globally but also locally.
- Large variability of SOC storage rates depending on soil type and climatic conditions and management options.
- Even an additional storage, less than 4‰ would help mitigate CO2 emissions.
- Farmers will not be able to adopt it: social and economical constraints (costs, need for continuous financial incentives).
- Address first the farm sustainability (SOC storage is likely to come with success in sustainable production).
- Demonstrate the benefits of soil carbon and related incentives.
3. Equilibrium and Non-permanence

- C storage is limited with time (equilibrium) and the rate of storage starts decreasing once storage is initiated.

- Non permanence of SOC storage

- Even an additional storage over a few decades would help mitigate CO2 emissions.
  - Predictions must account for these kinetics.

- Management practices should be sustainable in terms of crop production.

New management (e.g. increase C input)

Equilibrium with new management

Stop management
Advantages of paddy soils

• Slow decomposition under anaerobic condition
• Large amount of C enter soils as roots and stubbles even though straw is removed

More sustainable system than upland crop system
Let’s join the 4per1000!

• Although there are lots of criticisms
• To achieve food security and climate change mitigation

https://www.4p1000.org/c

Thank you for your attention!