The role of oil palm biomass recycling on soil health in plantations

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Contribution:

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II - **HEALTHY SOILS** TO SUPPORT THE ROLE OF AGRICULTURE IN SUSTAINABLE HUMAN DEVELOPMENT

9- As good stewards of the resource we stand by our responsibility to protect soils, water and biodiversity against degradation, loss and pollution. Therefore, we recall our last year’s commitments taken under German G20 presidency. We acknowledge that healthy soils are an essential non-renewable part of our planet’s natural resources and have a key role in food production, reduction of impacts of frequent and extreme weather events, and deliver essential ecosystem services. Their sustainable management and use is crucial for the contribution of agriculture to sustainable development, in all its dimensions. These essential soil functions are being seriously threatened by degradation in several regions.
Food and Nutrition Security: Improving Soils and Increasing Productivity

Executive Summary
Soils, water and energy are essential resources for ensuring food security in the world. Human pressures on soil resources are reaching critical limits. Main threats are erosion, loss of organic carbon, nutrient imbalances, salinization and sodification, loss of biodiversity, contamination, acidification, compaction and urbanization. In this context, the S20 affinity group makes the following specific recommendations for the sustainable management of soils:
1. Promoting good soil governance. Priorities should be given to
WE DEPEND ON SOILS

Soil health refers to the continued capacity of the soil to function as a vital living system within ecosystem and land-use boundaries, to sustain biological productivity, promote the quality of air and water environments, and maintain plant, animal, and human health (Brown, Stombaugh, and Haberman, 2021).

Healthy soils are the basis for healthy food production.

- Soils are the foundation for vegetation which is cultivated or managed for food, fibre, fuel, and medicinal products.

- Soils help to combat and adapt to climate change by playing a key role in the carbon cycle.

ECOSYSTEM SERVICES

Provisioning
- Food
- Fresh water
- Wood & Fibres
- Fuel
- ...

Regulation
- Climate regulation
- Flood regulation
- Disease regulation
- Water purification
- ...

Habitats & Supporting
- Nutrient cycling
- Soil formation
- Primary production
- Biodiversity
- ...

Cultural
- Aesthetic
- Spiritual
- Educational
- Recreational
- ...

Soil is a non-renewable resource in preservation in commodity feed, energy use, and in sustainable food and forests.

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## Oil palm cultivation and biomass production

### Biomass and Nutrient Recycling

<table>
<thead>
<tr>
<th></th>
<th>Biomass (dry) (t/ha)</th>
<th>Carbon (t/ha)</th>
<th>N (kg/ha)</th>
<th>P₂O₅ (kg/ha)</th>
<th>K₂O (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual recycling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fronds</td>
<td>9 (5-13)</td>
<td>5</td>
<td>95</td>
<td>8</td>
<td>135</td>
</tr>
<tr>
<td>EFB</td>
<td>2.4 (2.0-2.7)</td>
<td>1.2</td>
<td>41</td>
<td>12</td>
<td>110</td>
</tr>
<tr>
<td><strong>Replanting recycling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stem</td>
<td>61 (46-82)</td>
<td>30</td>
<td>281</td>
<td>31</td>
<td>775</td>
</tr>
<tr>
<td>Fronds</td>
<td>18 (10-27)</td>
<td>9</td>
<td>200</td>
<td>16</td>
<td>270</td>
</tr>
<tr>
<td>Roots</td>
<td>13 (8-20)</td>
<td>6</td>
<td>281</td>
<td>18</td>
<td>310</td>
</tr>
</tbody>
</table>
The key role of oil palm biomass for soil health

Four soil health components:
- The chemical
- The physical
- The biological
- The ecological

Oil palm biomass:
- Empty Fruit Bunches (EFB)
- Fronds
- Compost
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Oil palm biomass:
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The potential effect of EFB applications on chemical soil health

EFB and soil pH

EFB and soil $H_{\text{exch.}}$

EFB and soil $A_{\text{exch.}}$

The potential effect of EFB applications on chemical soil health.
The potential effect of EFB applications on chemical soil health

**EFB and soil Base saturation**

Impact of EFB application on soil Base saturation (av. during trial)

**EFB and soil C-Organc**

Impact of EFB application on soil C-Organic (averaged during trial)

**EFB and soil Al saturation**

Evolution Soil Al-sat after EFB application

- 0-5 cm
- 5-15 cm
- 15-25 cm
- 40-60 cm
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The potential effect of EFB applications on physical soil health

EFB and soil resistance to penetration

- Soil resistance to penetration before EFB application
- Soil resistance to penetration 32 days after EFB application
- Soil resistance to penetration 115 days after EFB application
The potential effect of EFB applications on physical soil health

Fig. 7 - Impact of EFB application on soil permeability

<table>
<thead>
<tr>
<th>Time (mn)</th>
<th>K₁ (cm/h)</th>
<th>K₂ (cm/h)</th>
<th>S₁ (cm/h)</th>
<th>S₂ (cm/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>39</td>
<td>55</td>
<td>114</td>
</tr>
</tbody>
</table>

Kinetic of soil humidity after EFB application (depth: 0-10 cm) (Deviner Method)

Kinetic of soil humidity after EFB application (depth: 10-20 cm) (Deviner Method)
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The potential effect of EFB applications on biological & ecological soil health

Table 2: Number of taxa macrofauna found (individuals/m²) during 15 times of observation (data collected from 5 replications)

<table>
<thead>
<tr>
<th>No.</th>
<th>Treatments</th>
<th>Number of taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Under EFB</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>Control</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>EFB</td>
<td>12</td>
</tr>
</tbody>
</table>
The potential effect of EFB applications on biological & ecological soil health

EFB and soil feeding activity

EFB and soil temperature

Soil temperature after EFB application (0-5 cm)
The potential effect of EFB applications on biological & ecological soil health

EFB impact on soil CO₂ and N₂O emissions

<table>
<thead>
<tr>
<th></th>
<th>N-applied</th>
<th>N-N₂O Emissions</th>
<th>E.F. % of N applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-Urea</td>
<td>9.4</td>
<td>0.302</td>
<td>1.20</td>
</tr>
<tr>
<td>N-EFB (*)</td>
<td>20.0</td>
<td>0.265</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Note: base line N₂O emissions = 0.00053 g/m² (ave. 3 days)  
(*) applied for 2 years
The key role of oil palm biomass for soil health

Four soil health components:
- The chemical
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- The ecological

Oil palm biomass:
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- Compost
The potential effect of fronds recycling on physical soil health

Frond spreading and water run-off

Frond spreading and soil erosion

Run-off and soil ground cover management effect of biomass recycling

Soil erosion and soil ground cover management effect of biomass recycling

Frond spreading and water run-off

Frond spreading and soil erosion

Run-off and soil ground cover management effect of biomass recycling

Soil erosion and soil ground cover management effect of biomass recycling
The potential effect of fronds recycling on chemical soil health

Frond spreading and nutrient losses

Phosphorus losses (% of P input) and soil ground cover management effect of biomass recycling

Potassium losses (% of P input) and soil ground cover management effect of biomass recycling
The potential effect of fronds recycling on chemical soil health

Frond spreading and soil characteristics: C, pH, N, K
(Aholoukpe et al., 2016)
The potential effect of fronds recycling on chemical soil health

Frond spreading and C-org looses

Total Organic carbon losses and soil ground cover management effect of biomass recycling
The potential effect of fronds recycling on biological soil health

Frond spreading and soil feeding activity

Frond spreading and insects

Frond spreading and earthworms
The key role of oil palm biomass for soil health

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Oil palm biomass:
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The potential effect of Compost on biological soil health

Compost application and soil feeding activity

*BLS: Bait Lamina Stick
and what impact on ..... 
...... palm productivity
The key role of oil palm biomass for soil health

The capacity of biomass recycling to maintain high yield
Impact of Empty Fruit Bunched application on oil palm yield (5 years average)

Yield 5 years average (t FFB.year$^{-1}$)

EFB application rate (t.ha$^{-1}$.year$^{-1}$)

SBYE 03 - Empty fruit bunch and Yield 2004-08 (5 y)

SPNE 03 - EFB and Yield 2004-08 (5 years)

Biomass recycling (EFB) and yield
Biomass recycling (compost) and yield

Effect of compost application rate (kg dry matter/palm.year$^{-1}$)

Yield (tonne FFB/palm)

- Control (min fert)
- Compost 15 kg/palm (5 kg dry)
- Compost 45 kg/palm (15 kg dry)
- Compost 70 kg/palm (25 kg dry)
Conclusion
The role of oil palm biomass recycling on soil health in plantations

The is a high potential impact of biomass recycling on soil health for oil palm sustainability
Field practices can be optimized

Opportunities exist: metagenomics, sensors, remote observations, analytics, deep-learning (AI)

There is a need to develop global soil health indicators (GISQ, Biofunctool, ...)

Muchas Gracias