

# *les dossiers* **d'AGROPOLIS** INTERNATIONAL

*Expertise of the scientific community*

Special Partnership Issue



## **Agroecological transformation for sustainable food systems**

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Similarly, the ring-shaped spatial organization of village lands and the presence of trees in the form of wooded parkland have been maintained despite the major constraints these production systems have faced over the last century (decreased rainfall, population growth, changing socioeconomic conditions). Finally, human societies have gradually adapted to help sustain agricultural activity (migration, off-farm work and income, family and social ties, etc.). These systems-based multidisciplinary analyses are essential to come up with effective ways to boost the carbon content of cultivated soils. This knowledge, combined with local know-how, will pave the way for efficient, sustainable and transferable agricultural practices or social arrangements. The Fondation Agropolis

DSCATT\*\* flagship project is being implemented in this setting with the aim of developing and testing methods and tools to co-build soil carbon sequestration strategies with stakeholders.

\*CERAO project (2014-2018), Auto-adaptation of tropical agro-socio-ecosystems to global climate change? ANR Agrobiosphère: [www.umr-ecosols.fr/en/recherche/projects/17-projets/44-cerao](http://www.umr-ecosols.fr/en/recherche/projects/17-projets/44-cerao)

\*\*DSCATT project (2019-2023), Agricultural Intensification and Dynamics of Soil Carbon Sequestration in Tropical and Temperate Farming Systems: [www.dscatt.net](http://www.dscatt.net)

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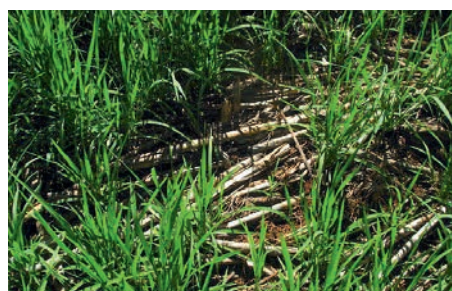
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## Why should the priming effect be considered in agroecology?

Organic matter (OM) mineralization by soil microbial communities is a major nutrient source for plants and leads to a 7-fold higher global release of CO<sub>2</sub> into the atmosphere compared to anthropogenic emissions. It is hence essential to gain insight into the mechanisms involved to ensure the success of the agroecological transition and for climate change mitigation via soil carbon (C) sequestration. The priming effect (PE) is a key mechanism contributing to the ecosystem carbon balance. PE has long been viewed as a net soil C loss since it stimulates soil OM mineralization following fresh OM input. Yet it can serve as an efficient nutrient supply for plants if the system is in equilibrium (i.e. mineralization = C storage). PE is hard to measure *in situ* and is the outcome of several processes, each driven by its own microbial constituents and targeting a different OM pool. The balance between C gain and loss depends on: (i) the efficiency of microorganisms in facilitating biomass C uptake; and (ii) the age of the destabilized OM pool (recent dynamic rather than

old stabilized OM). Although problematic from a carbon balance standpoint, a process geared towards a stabilized OM pool could enhance fertility via nutrient (N and P) remobilization. Plants naturally initiate this type of process in their rhizosphere depending on their needs. In summary, **PE can be beneficial in agroecology by controlling processes via agricultural practices, depending on the target issue —C storage and/or crop nutrition. Organic input quality management is also a highly promising thrust.**



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◀ Rainfed rice under maize crop residue at Andranomanelatra, Madagascar.

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## Effective recycling in oil palm plantations

*Reducing economic and environmental costs*



Palm oil is currently the top-ranking vegetable oil consumed worldwide and production shall continue to increase. Agroecological practices should therefore be implemented to an increased extent in plantations. Oil palm plantations require fertilizer applications, which account for 46–85% of field costs while substantially contributing to environmental impacts such as acidification and climate change<sup>(1)</sup>. Agroecological practices help reduce external inputs via the recycling of highly diversified and plentiful coproducts<sup>(2)</sup>. Oil palm plantations can generate a total of ~16 t/ha.yr<sup>-1</sup> of coproducts, besides the palm and kernel oils produced (~5 t/ha.yr<sup>-1</sup>). This biomass consists of fronds, stipes, empty fruit bunches (EFB), palm oil mill effluents, shells and fibers.

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◀ Field application of compost from palm oil residues, Indonesia. © C. Bessou/CIRAD

During the immature stage, the temporary legume cover brings benefits by recycling nutrients from decomposing stipes from the previous harvest, while also preventing weed development. **Then throughout the crop cycle, field application of EFB as an organic amendment proved to have substantial advantages.** Application of this coproduct can improve the soil nutrient content but it also further enhances the soil physicochemical properties and biota through various mechanisms, thereby protecting the soil and its functioning capacity<sup>(2)</sup>. Moreover, EFB may be co-composted, notably with palm oil mill effluent, thus increasing the nutrient value and stability of the amendment while reducing transport costs as well as environmental impacts from effluent treatment<sup>(3)</sup>. Harnessing the most

from the co-product recycling potential implies accounting for the benefits and risks jointly at the palm agroecosystem and supply chain levels. Life cycle assessment (LCA) facilitates such a holistic analysis by considering potential substitutions and avoided impacts, as well as trade-off risks<sup>(1,4)</sup>. **LCA results have highlighted that residue compost could replace 10–25% of synthetic fertilizers while markedly reducing the climate change impact<sup>(3)</sup>.** However, despite the great quantities of coproducts generated, demand within the palm value chain or outside may exceed supply, so competition and fertility transfer issues would need to be investigated to highlight sustainable practices at the landscape level.

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## Mechanized composting to convert crop residues into organic fertilizer

In-field burning of crop residues is currently a serious issue, causing GHG emissions and air pollution in many Asian countries such as India or Vietnam<sup>(1)</sup>. This adverse traditional practice could be reduced by converting crop residues mixed with animal manure into organic fertilizer to enhance soil fertility and crop yield<sup>(2)</sup>. Mechanized rice straw composting developed under an IRRI-led project<sup>(1)</sup> is an innovation that combines physical and biochemical processes to optimize the rice straw decomposition efficiency and organic fertilizer quality (Figure). This technology optimizes the composting process and efficiently addresses affected parameters such as the C/N ratio, temperature, moisture

content, pH, bioactiveness, anaerobic and aerobic conditions. Rice straw composting using this technology takes about 45 days, i.e. about half the time required for traditional practices such as manual composting and bulldozer mixing.

**For sustainable rice production, particularly for the ‘three cropping seasons per year’ approach, we suggest two options to avoid rice straw burning and elevated methane emissions: (i) producing organic fertilizer from rice straw, including mechanized collection<sup>(3)</sup> and composting<sup>(1)</sup>; and (ii) composting and recycling rice straw for organic rice production.** Indeed,

1 ha of rice production requires about 6–10 t of compost produced from the same amount of rice straw mixed with 20–40% of animal manure to achieve an optimized C/N ratio of 25/1. GHG emissions from rice straw composting are about 200–300 kg CO<sub>2</sub>/t of straw<sup>(4)</sup>. In addition to the added value from rice straw, mechanized rice straw composting resulted in a significant GHG emission reduction compared to raw rice straw incorporation. Furthermore, avoiding rice straw burning is also a criterion to qualify under the global Sustainable Rice Platform Standard that enable the rice product meeting the premium markets and driving its price increased.

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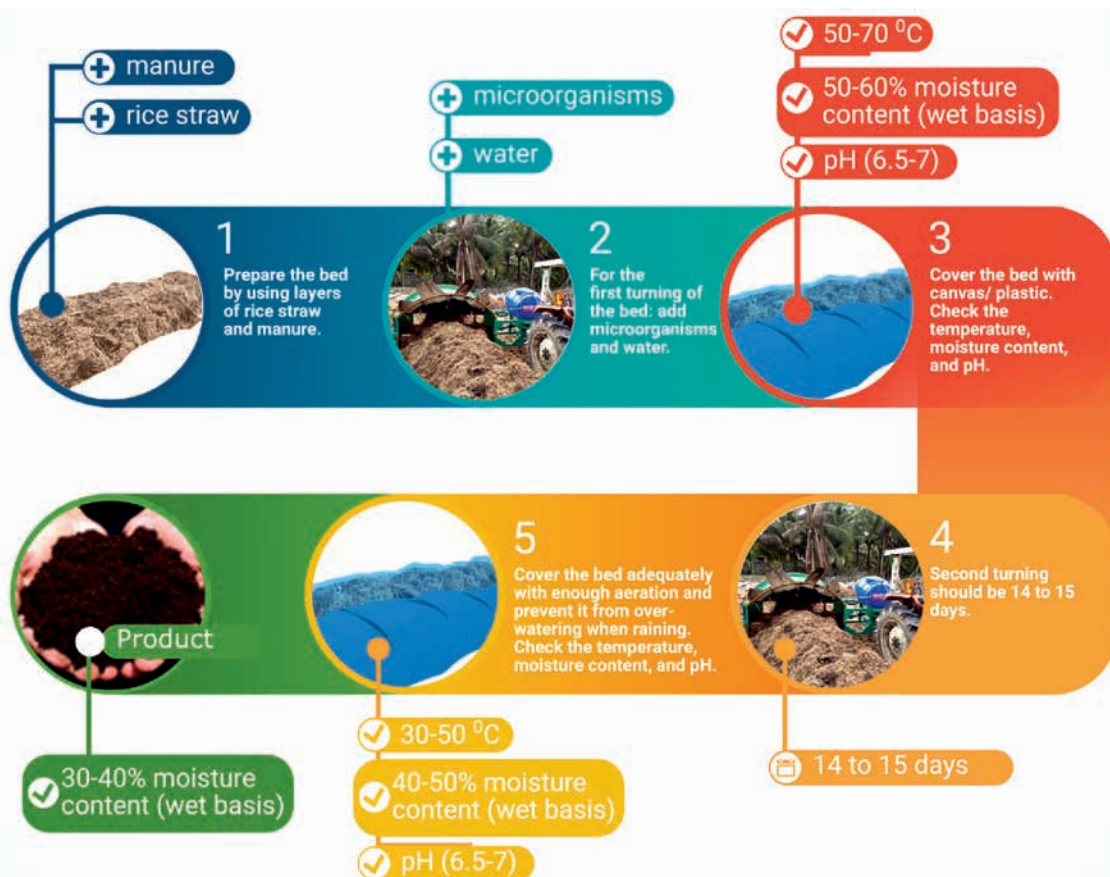
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▲ Rice straw composting process.