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Energy and Carbon Footprints of Biofuel Systems using Banana and Plantain Waste

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Abstract

Waste that accumulates in *Musa* production systems (up to 40 % of total fruit biomass) has a great potential to be processed into bioethanol due to high sugar contents of fruits, and can open new energy sources and markets for small-scale banana and plantain producers. However, the economical and ecological sustainability of biofuel systems strongly depends on how they are produced.

The present study aimed to analyse energy and carbon footprints of *Musa* bioethanol production systems using a life cycle approach. The study compares three case studies differing in management practices, which are (1) a coffee producer's cooperative in Costa Rica using *Musa* as shade trees, (2) organic banana producers from Ecuador, and (3) conventional banana producers from Ecuador.

The best net-energy balance (19.3 MJ L^{-1}) was obtained for the case study from Costa Rica, closely followed by the organic producers from Ecuador (17.1 MJ L^{-1}), which are *Musa* production systems operating with low external inputs. The net-energy balance for the conventional banana farms in Ecuador was significantly lower (7.2 MJ L^{-1}), mainly due to the high amount of energy required for producing external inputs such as mineral fertilisers and pesticides. All three case studies yielded avoided carbon emissions (C emissions that are avoided when biofuels are used instead of petroleum based fuel), with the best value obtained for the Costa Rican case study (0.48 kg C L^{-1}), followed by the organic (0.44 kg L^{-1}) and the conventional (0.34 kg L^{-1}) banana producers from Ecuador. 40-100 % of gasoline consumption of farm households could be replaced by bioethanol, thereby saving C emissions in the range of 226-1038 kg yr^{-1}.

The study clearly showed the need to conduct feasibility studies that consider economic as well as ecological aspects. Biofuel systems should aim at having more favourable energy and carbon balances than fossil fuels, which will open opportunities for carbon credits and new markets.

Keywords: Biofuel, carbon, Costa Rica, Ecuador, energy, life cycle analysis, markets, *Musa* spp

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