Tropentag, September 14-16, 2010, Zurich

"World Food System —
A Contribution from Europe"

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

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Abstract

Waste that accumulates in Musa spp. production systems (up to 40 % of total fruit biomass) has a great potential to be processed into bioethanol due to the starchy nature 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 spp. 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 spp. as shade trees, **(2)** organic banana producers from Ecuador, and **(3)** conventional banana producers from Ecuador.

The best net-energy balance (12.02 MJ L^{-1}) was obtained for the case study from Costa Rica, which is a Musa production system operating without external inputs. The organic banana production system of Ecuador also resulted in a positive net-energy balance (5.83 MJ L^{-1}), but only about as half as high as that for Costa Rica. The net-energy balance for the conventional banana farms in Ecuador was highly negative (-8.67 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 (0.58 kg C L^{-1}), followed by the organic (0.43 kg L^{-1}) and the conventional (0.19 kg L^{-1}) banana producers from Ecuador. Apart of energy inputs due to management practices, transportation of feedstock from field to the processing plant happened to be an extremely important variable, which may account for 40–90 % of total energy inputs, and can result in negative sustainability indicators.

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.

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Keywords: Biofuel, carbon, Costa Rica, Ecuador, energy, life cycle analysis, markets, musa spp.