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Using Life Cycle Assessment Tools to Evaluate the Environmental Impact of Rubber-Based Production Chains

DANIEL GLEMSER, MELVIN LIPPE, GEORG CADISCH

University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany

Abstract

Currently all natural rubber for industrial purposes originates from the tropical tree *Hevea brasiliensis*. However, alternative sources are needed given the emerging environmental concerns of Hevea cultivation and the rising global demand of natural rubber. The shrub Guayule (*Parthenium argentatum*) represents one of the potential candidates to partly replace Hevea-based rubber products. This depends on the available rubber yield, produced greenhouse gas emissions (GHG) and energy required during the production cycle among others. Life cycle assessment (LCA) has become an indispensable tool to assess environmental impacts of industrial production chains. The strength of a LCA lies in its holistic consideration of all processes and production steps which are necessary to manufacture a selected product. The presented study aims to evaluate if Guayule-based rubber can be a potential competitor to Hevea rubber with regard to GHG emissions and total energy balance. The chosen system boundary extends from crop cultivation to the processing of rubber-sheets. LCAs were computed for Hevea- and Guayule-rubber production chains individually (baseline), and compared to a series of yield and co-product use scenarios. LCA computations revealed that the baseline Guayule production chain emits 7.74 Mg CO₂-Equivalents per ton of produced natural rubber compared to 0.67 Mg of CO₂-Equivalents emitted by Hevea-based rubber. Once Guayule co-products such as bagasse are considered, a decrease of GHG emissions by 0.46 Mg CO₂-Equivalents compared to a Hevea production chain without co-product utilisation occurs. When Guayule rubber yields increase from 0.32 to 1 Mg ha⁻¹ a⁻¹, GHG emissions decrease to 0.37 compared to 0.43 Mg CO₂-Equivalents for the chosen Hevea production chain. Overall, both production chains show a positive energy balance, although Guayule requires 108.148 MJ more energy compared to Hevea-based rubber sheets. The study revealed that Guayule is a potential competitor of Hevea rubber, if co-products can be utilised as internal energy source during the production chain. Further research could focus on field-based studies to evaluate Guayule's yield potential under different agronomic regimes, as well as on technical improvements to reduce the energy demand during the cultivation and production steps of Guayule-based rubber.

Keywords: Guayule, *Hevea brasiliensis*, life cycle assessment, *Parthenium argentatum*, rubber-based production chain