7° Congresso da Rede Brasileira de Tecnologia e Inovação de Biodiesel

LCA of macauba production system: a potential perennial energy crop

Alexandre Nunes Cardoso (Embrapa Agroenergia, alexandre.cardoso@embrapa.br), Thiago Oliveira Rodrigues (IBICT, thiagorodrigues@ibict.br), Pedro Marques (ADAI-LAETA, Mechanical Engineering Department, University of Coimbra, pedro.marques@dem.uc.pt), Fausto Freire, (ADAI-LAETA, Mechanical Engineering Department, University of Coimbra, fausto.freire@dem.uc.pt), Érica Castanheira (ADAI-LAETA, Mechanical Engineering Department, University of Coimbra, erica@dem.uc.pt)

Key words: Biomass, bioenergy, palm.

1 - Introduction

Macauba (*Acrocomia Aculeata*) is regarded as a promising alternative biomass for the production of oil for biofuels and other products.

Although environmental potential impacts have been reported from the agricultural phase of bioenergy crop products, applying LCA to perennial crops such as macauba palm, requires that productive and unproductive stages along the lifecycle of the crop be taken into account (Bessou et al., 2013; Alaphilippe et al., 2014).

A recent study on macauba palm cultivation LCA (Fernández-Coppel et al., 2018), assessed environmental impacts for macauba palm product system through three methods being one an endpoint method. This study intends to apply midpoint impact categories for the life cycle impact assessment for a distinct LCInventory, aiminger to contribute to the improvement of macauba crop system.

2 - Material and Methods

2.1 Characterization of the system

The reference region for the study is the central-west region of Brazil, one of the regions where macauba palm naturally occurs, and where commercial crops began to be established. Experimental data for the non-productive phase, and prospective data for the latter years of the productive phase will be used, considering that macauba crop in the country is recent, and there are few established commercial plantations.

A single crop is considered for the sudy with the following characteristics: seedlings of macauba with 1-year cycle were planted in a 5m by 5m spacing, totalizing 400 plants/ha. The area was irrigated along the first year to ensure a good plant establishment on the field. Fertilizer application considered a one 1 ha, following the recommendation of Motoike et al., 2013.

2.2 Perennial crop cycle modeling

As suggested by Bessou et al. (2013) three possible approaches regarding LCA can be applied to modeling perennial crop cycle: spatial, modular and chronological assessment. In the modular assessment, each phase of the crop cycle is modeled independently, and according to the author this approach would fulfill the minimum requirements to account for the perennial cropping cycle.

For this study, three phases are considered: nursery, a one-year period for seedlings production, encompassing a pre-nursery period; no productive or maintenance phase, which includes planting and crop maintenance activities, for the following 5 years, and a production phase, which is assumed to be a 20 years period until the replanting. Altogether, it is totalizing 26 years cycle.

For the purpose of the inventory, the inputs along the pre-nursery and nursery are within the nursery phase for a twelve months period. Plastic bags used for seedlings development are not recycled. Water consumption for the irrigation of the seedlings is considered. The impacts of infrastructure for the nursery activities are not considered.

The maintenance phase consists of the period of plant's development on the field, from the planting of the seedlings until the beginning of production. Soil preparation and planting of the seedlings activities are included, as well as required inputs on the field, such as fertilizers, pesticides and others until the beginning of production are considered as well. In addition, it is considered that the establishment of the plants during the dry season of the first year needs a supplementary irrigation, which is accounted for. It is assumed that the plants will produce for a period of 20 years, which consists of the production phase. Data available from field experiments run up to the 10th year is considered, with a projection of the production along the following years, taking into account the recommended increments of fertilizers along the productive cycle.

The reference for the inventory is 1 ha of macauba in the Center-West region of Brazil, considering a promising scenario based on an estimation of 53 tons of fruits per ha, based on natural populations (Conceição et al., 2015), for a density of 400 plants per ha.

2.3 LCA Goal an Scope

Following the ISO 14040 standard, the LCA goal is to assess potential environmental impacts of 1 ton of macauba fruit production from continuous agricultural land use, a typical pattern in perennial crops.

The product system is defined as a cradle-to-farm gate (Figure 1), including the land preparation and all upstream processes, transport, applied inputs to the field and field operations up to fruit collection.

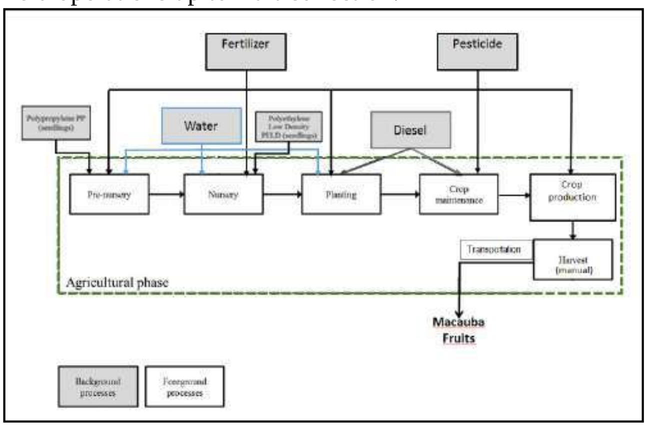

Figure 1. Product system for macauba fruits production.

The previous use of the land was pasture and direct or indirect land use change was not taken into account. The end of life of plantation, which would include the replantation activities, is not included.

The geographical coverage of the system is partial, where the main processes were modeled on a regional basis, and the auxiliary processes come from the database (Ecoinvent DB).

Technological coverage is partial, and the main processes represent recommended technologies to the crop system.

All relevant data are collected and complemented by secondary data from Ecoinvent DB. The output data, especially emissions, is calculated considering the inputs, by applying to the subject equations and models available in technical and scientific references.

The Recipe Midpoint **v.1.07** method was applied to assess potential environmental impacts for the following impact categories: climate change, fossil depletion, terrestrial acidification, freshwater eutrophication, marine eutrophication, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity and water depletion.

3 - Results and Discussion

As expected, a greater proportion of the potential environmental impacts per ton of macauba were generated during the production phase (Figure 2), which represents a longer period than maintenance phase.

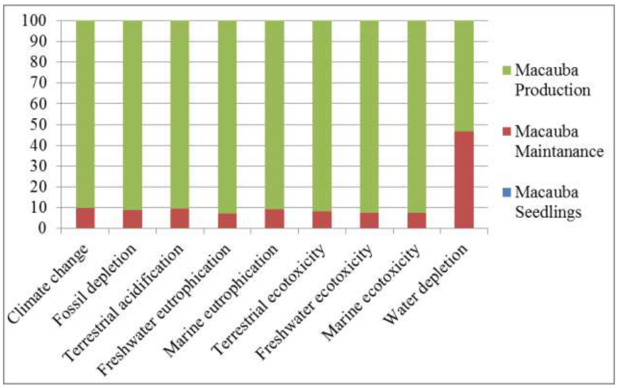

Figure 2. Life cycle impact analysis for 1 ton of macauba fruits for each phase of cultivation.

Increasing demand for fertilizers along this period, based on current recommendation, also results on high impacts. This result is observed for all impact categories, with exception of water depletion category, for which almost half of the potential impacts originated from the establishment phase.

Even requiring agricultural inputs and water, considering whole crop cycle, the seedling production phase impacted less than 0.007% for all impact categories.

Along the production phase of macauba palm, fertilizers production processes contribute more, to potential environmental impacts for most of the impact categories, especially of phosphate and urea (Figure 2).

A different pattern is observed for the categories climate change, terrestrial acidification and marine eutrophication (Figure 3). Emissions of mainly nitrogen compounds to air and water, and part of fossil CO2, promote strong impacts, which are jointly represented by the macauba production process in figure 3, as a result of fertilizer application to soil.

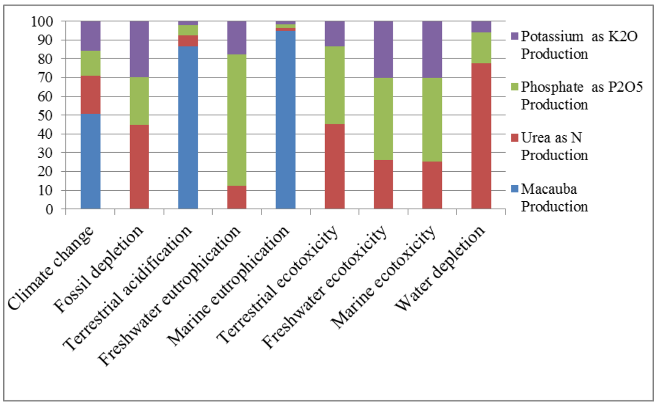

Figure 3. Life cycle impact analysis of 1 ton of macauba fruits for the production phase.

4 – Conclusions

Along the crop cycle, the production phase encompasses the greatest proportion of impacts.
Water used for irrigation during plants establishment is of significant impact.
Fertilizers, especially phosphate and urea are the main contributors for potential environmental impacts for all impact categories based on 1 ton of macauba fruits production; corroborating recently published data.
Recycling of nutrients contained in macauba leaves shall be considered in future studies as a way to reduce the application of mineral nutrients.

5 – Agradecimentos

CIE - Universidade de Coimbra

6 - Bibliografia

ALAPHILIPPE, A. BOISSY, J.; SIMON, S.; GODARD, C. Using of the LCA methodological framework in perennial crops: Comparison of two contrasted European apple orchards. 9th International Conference LCA of Food San Francisco, USA 8-10 October 2014.
BESSOU, C.; BASSET-MENS, C.; TRAN, T.; BENOIST, A. LCA applied to perennial cropping systems: a review focused on the farm stage. *International Journal of Life Cycle Assessment* **2013**, 18:340-361.
CONCEIÇAO, L. D. C. S.; JUNQUEIRA, N. T. V.; MOTOIKE, S. Y.; PIMENTEL, L. D.; FAVARO, S. P.; BRAGA, M. F.; ANTONIASSI, R. Macaúba. In: Lopes, R.; de Oliveira, M. do S. P.; Cavalari, M. M.; Barbieri, R. L.; Carson, L. D. H. (Ed). Palmeiras nativas do Brasil. Brasília, DF : Embrapa, 2015. p. 269-305.
COPEL, I. A.; EVARISTO, A. B.; GUIMARÃES, A. C.; GIL, J. M.; GRACIA, L. M. N.; RAMOS, P. M. Life cycle analysis of macaúba palm cultivation: A promising crop for biofuel production. *Industrial Oil Crops & Products* **2018**, 125:556-566.
MOTOIKE, S. Y.; CARVALHO, M. C.; PIMENTEL, L. D.; KUKI, K. N.; PAES, J. M. V.; DIAS, H. C. T.; SATO, A. Y. *A cultura da macaúba: implantação e manejo de cultivos racionais*. Viçosa-MG: Editora UFV, **2013**. 61p.