LIFE CYCLE ASSESSMENT OF SISAL PRODUCED IN SEMIARID REGIONS IN BRAZIL

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ABSTRACT

Sisal (*Agave sisalana*) is a natural fiber produced in Brazil in marginal semi-arid areas where represents an important source of income for the local population. This study assessed the environmental performance of sisal production in this context. Its production process has low technological level and low inputs, which implies low yield per hectare, but also low environmental impact, compared to other agricultural products. The main sources of impacts are agricultural and processing operations.

INTRODUCTION

Sisal is the main hard fiber produced in the world. In Brazil, 99 thousand ha are dedicated to its cultivation, producing 80 thousand tons of this fiber. The main producing state is Bahia, responsible for 94% of the national production (IBGE, 2017). Its cultivation occurs in the semi-arid region, where few agricultural activities are feasible, due to the scarcity of water. It is practiced by family farmers and constitutes an important source of jobs and income in this region of extreme poverty. The production system adopted is very low-tech, resulting in low productivity and, consequently, low profitability.

The objective of this work was to evaluate the environmental performance of sisal produced in the semiarid region of Bahia, identifying its critical points. This information can guide process improvements, contributing to increase the sustainability of this activity.

Attributional Life Cycle Assessment with a cradle to gate approach was used. The sisal production system was described by experts. For the Life Cycle Inventory, the background processes came from the ecoinvent database v.3.4. The Life Cycle Impact Assessment (LCIA) adopted the software SimaPro v.8.5.2 and the method ReCiPe Midpoint H v.1.12/W. Land use changes (LUC) and their emissions were estimated according to Novaes et al. (2017).

RESULTS AND CONCLUSIONS

The production of sisal in Bahia has low technological level. Although there are some variations, the most common production system adopts spacing 3 m x 1 m and mechanized tillage and includes: area selection, mechanized tillage, planting, replanting, fertilizing, cultivation, harvesting and processing. The only inputs used in the sisal production are diesel for mechanized operations and grass seeds, planted between the lines. Sisal seedlings correspond to sprouts from adult plants; synthetic fertilizers and pesticides are not used. The average agricultural yield is 939 kg ha^{-1} (IBGE, 2017). In the processing of sisal, fuel oil and lubricants are used.

Regarding to LUC, there was an 18% expansion of the sisal production area over a period of 20 years, increasing from 163,352 ha, average of the triennium 1995-1997, to 199,494 ha, average of 2014-2016. This expansion occurred mainly on native vegetation, which resulted in the emission of 1.2 t CO_2 ha^{-1} $year^{-1}$. In 2017, however, due to a drastic drought, there was a reduction in the area occupied by sisal in Brazil to about half of the area of the previous year, causing a reduction of the net area in 20 years - therefore the LUC is considered null. It is worth noting the high degree of uncertainty related to this type of estimation.

The most relevant environmental impact of the sisal life cycle is “agricultural land occupation” (ALO). This natural resource is compromised by low yield per area of the sisal crop. The agricultural process itself affects only this category of impact (ALO) and, if LUC is considered, the category climate change. Three processes affected all impact categories (except ALO): agricultural operations (ploughing and harrowing); grass seed production; and fuel oil production. The impacts caused by agricultural operations are a consequence of diesel consumption: in climate change, the impact is due to fossil CO_2 and fossil CH_4 emissions; in photochemical oxidants, to NOx emissions; and in freshwater ecotoxicity, to heavy metal emissions. These operations also caused metal depletion, by its consumption in the machinery structure. Grass seed production caused “terrestrial acidification” due to NH_3 emissions; and terrestrial ecotoxicity, due to emissions of heavy metals - from the use of fertilizers. The production of fuel oil caused impacts by consuming fossil resources and by the emissions from its extraction, which affected ozone depletion and ionizing radiation (Fig 1).
Compared to sugarcane, for example, another semi-perennial crop widely cultivated in north-eastern Brazil, the impacts caused by the production of sisal are much lower. This is especially due to the very low consumption of agricultural inputs. The improvement of the environmental performance of this crop depends mainly on the increase in yield, which is known to be limited by edaphoclimatic conditions. Also its processing could be improved, with the development of more efficient equipment.

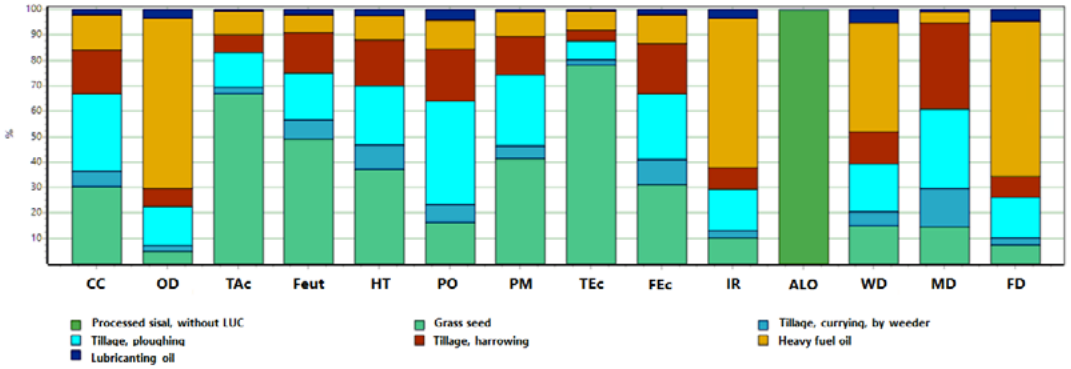

Fig 1. Life cycle assessment of processed sisal. CC: climate change; OD: ozone depletion; Tac: terrestrial acidification; Feut: freshwater eutrophication; HT: human toxicity; PO: photochemical oxidants; PM: particulate matter; Tec: terrestrial ecotoxicity; Fec: freshwater ecotoxicity; IR: ionising radiation; ALO: agricultural land occupation; WD: water depletion; MD: metal depletion; FD: fossil depletion.

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