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ENVIRONMENTAL SUSTAINABILITY ANALYSIS IN THE CANOLA OIL PRODUCTION FOR BIOFUELS

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Abstract. *Canola is among the oilseeds with the highest production volume in the world. In Brazil, it has the potential to meet a demand for diversification of raw materials for biofuels production, including the aviation sector. This highlight is due to this capacity to integrate within the systems of other grain's annual production. In this sense, it is relevant to evaluate canola's environmental profile, as an alternative biomass, to explain the potential environmental impacts. Thus, the present work's objective is to elaborate a life cycle inventory (LCI) of the canola production considering its two main products, degummed oil and dry bran. The analysis of the life cycle inventory, standardized by ISO 14040, involves the data collection and calculation procedures to quantify the relevant inputs and outputs of a product system. Preliminary results indicate that the greatest consumption of fossil fuels that occurs in the agricultural phase, as well as the use of chemical products, promotes potential environmental impacts, but the process that most contribute to the emissions is the canola oil production. This analysis also indicated that external and internal processes have an expressive contribution to environmental impacts.*

Keywords: *canola, oil, life cycle inventory, biofuel*

1. INTRODUCTION

Canola is a cultivar belonging to the *Brassicaceae family* (*Cruciferae*) that comprises about 350 genera and 3000 species (BARTHET, 2016). Nationally only hybrids of this culture are used. Its name is an international generic term referring to rapeseed cultivars with low levels of erucic acid and glucosinolates, suitable for human and animal consumption. This oil can be used as a raw material for biofuels' production (MORI, 2019a). This temperate oilseed can be grown in tropical regions, such as the low latitude savannas of Brazil. A considerable part of South America's tropical and subtropical grain production regions has the potential to meet the growing world demand for products derived from this grain, such as proteins and high-quality oil (TOMM, 2018).

Several factors stimulate canola's choice as an alternative for variation in crop rotation systems (MORI, 2019b). Some of them are the insertion of hybrids cultures with greater genetic resistance and tolerance to herbicides, added to improvements in crop management, growing demand for better quality vegetable oils, the need to replace fossil fuels and the formation of means of commercialization, are all

In the southern region of Brazil is where most of the research and production of canola are concentrated. Especially in the states of Rio Grande do Sul and Paraná, promoted by the existence and proximity of processing grains industries, making driving easy to access cultivation technique and commercialization (TOMM et al., 2009). The potential to compose crop rotation systems in the off-season and autumn-winter period is another prominent factor of this crop

(TOMM et al., 2009). This possibility allowed the canola tropicalization and the expansion of cultivation to subtropical regions such as the Cerrado Mineiro.

According to the National Supply Company (CONAB), in its Monitoring of the Brazilian Grain Harvest in July this year, the estimated area of canola planted in the country is 35,100 ha, with grain yield of 1,581 kg/ha and production of 55,500 tons of grains (CONAB, 2020). Given this scenario, it is possible to observe the need to evaluate canola's environmental profile. Thus, allowing to explain its impacts on the environment as an alternative or complementary input to soy to produce alternative biofuels production.

The aviation industry accounts for more than 2% of global carbon dioxide (CO_2) emissions (MONCADA, 2019). Based on this, it was observed in the last decades that several companies and agencies' growing interest in developing alternative fuels for the aviation sector (CREMONEZ, 2015). Because canola is one of the most important oilseeds growing in the world, responsible for 16% of vegetable oil production and ranking third in the world in oil production, behind only soybean oil and palm oil, it is possible to notice its potential as raw material for biofuels production (CONFORTIN, 2019).

In this scenario, detailed feedstock production information is necessary to accurately assess the biofuel life-cycle impacts (SIEVERDING, 2016). This information can be provided using the life cycle inventory (LCI) structure since it involves studying elementary inputs and outputs flows for a product system. The LCI analysis, standardized by ISO 14040, is commonly known as the second phase of the Life Cycle Assessment (LCA) methodology. The LCA is a systematic approach tool for environmental aspects related to the production process, promoting a more transversal view and supporting the decision making for environmentally effective management (SILVEIRA, 2017).

The LCI studies cover three phases, the definition of objective and scope, inventory analysis and interpretation. It also involves data collection. In this stage, the inputs of energy and raw materials, products, co-products, waste, air emissions, discharges to water and soil and other environmental aspects are identified. Another essential step for the LCI development is calculation procedures aiming to quantify the production system's relevant inputs and outputs. Finally, the collected data is validated and correlated to the elementary processes, reference flows, and functional units (ABNT, 2009). The following figure shows the main phases of the LCI, who are direct related to the LCA methodology.

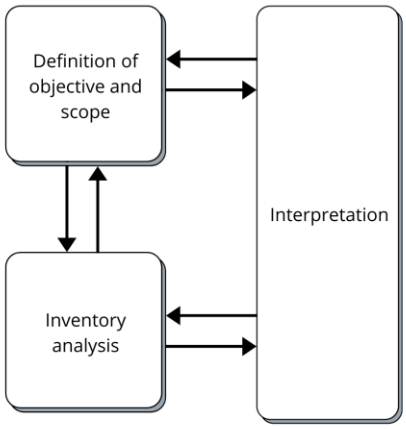

Figure 1. Phases of life cycle inventory. Adapted from (ABNT, 2009).

Thus, the present work's objective is a canola production LCI elaboration. The assessment considers the states of Rio Grande do Sul, Paraná and Minas Gerais and contemplates its two main products, degummed oil and dry bran.

2. METHODOLOGY

In this analysis, the system's limits include canola's agricultural production up to the exit gate of the industrial unit responsible for the vegetable oil extraction and bran production. In this study, the LCI structure is applied to evaluate hotspots, critical points that most contribute to the canola oil production chain's potential environmental impacts.

The data collection to analyze this grain production's agricultural phase was carried out by consulting the literature. The main guide work of this research was the "Survey of technologies used in the cultivation of canola by producers in Rio Grande do Sul, Paraná and Minas Gerais" (MORI, 2019a), a publication by Embrapa Trigo, the entity responsible for a series of research involving the cultivation of canola in Brazil. Information was extracted on the management, conservation and chemical correction of soil, sowing, seed treatment with pesticides, fertilization, phytosanitary management, weeds, pest insects and disease, and finally, the harvest.

To analyze the industrial phase, information about the canola oil processing was provided by a company that manufactures vegetable oils for human consumption. The primary data were collected by filling out forms normally used for the inventories construction. Processes regarding the grain's reception and storage, preparation, extraction, oil degumming and bran production were included.

In this way, it was possible to calculate the inputs and outputs of the primary processes of both phases. Using as reference the work "Life Cycle Inventories of Agriculture, Forestry and Animal Husbandry - Brazil" (FOLEGATTI, 2018), nitrogen and carbon dioxide emissions to the environment were calculated during the agricultural phase, for the calculations it was considered a productivity of 1,010 kg/ha (MORI, 2019a). The following figures display the analyzed agricultural and industrial phase flowcharts.

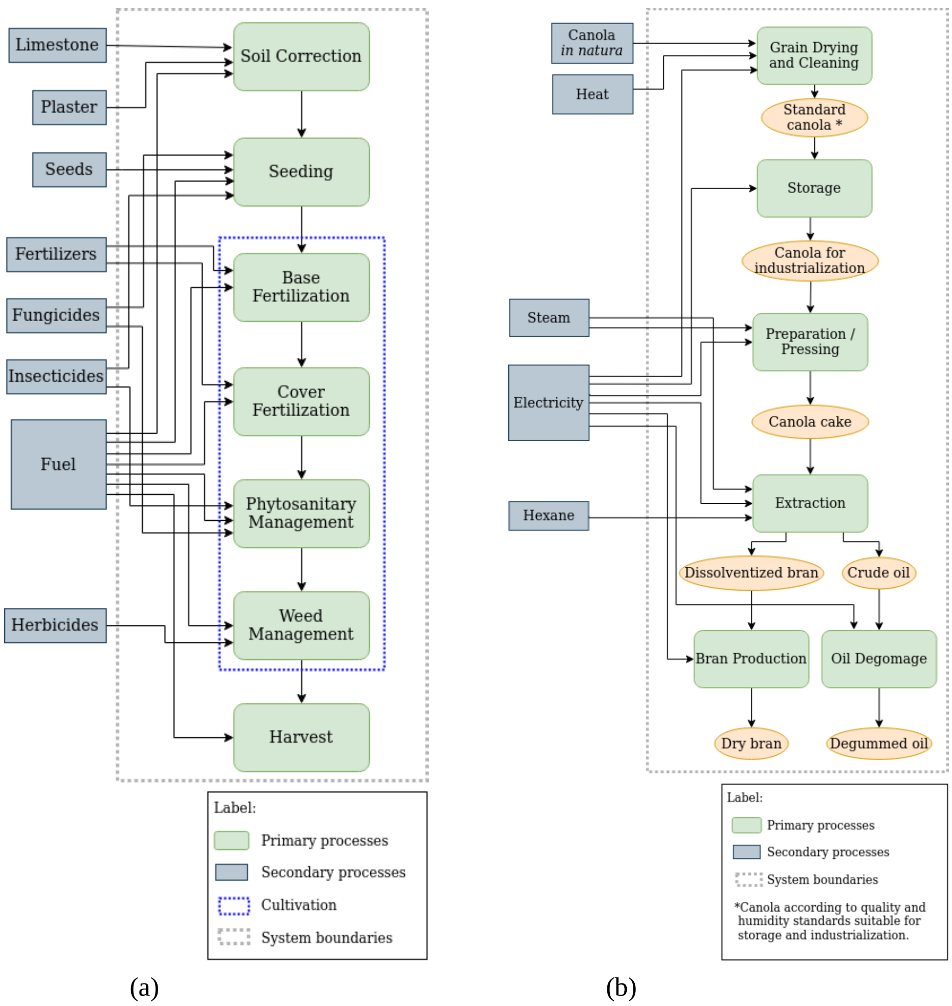

Figure 2. Flowchart of the analyzed processes. Where (a) is the agricultural phase flowchart and (b) is the industrial phase flowchart.

The technological model of the canola production system was established and modeled using openLCA software version 1.10.3. This free and open-source software for life cycle systems modeling can calculate and provide the environmental, social and economic system's indicators (GREENDELTA, 2020). For this preliminary study, secondary data were obtained from three different processes provided by the ecoinvent 3.7 database (ECOINVENT, 2020), including the production of soybean grain, oil and bran in Rio Grande do Sul state, Brazil.

Due to the similarity in the cultural treatment and industrial processing between the two mentioned oilseeds, primary data collected for canola LCI were inserted and considered through the calculations and analysis. The functional units adopted for this research are the production of 1 kg of canola grain, 1 kg of canola oil and 1 kg of canola bran, for each one of the processes using the software.

This study aims to measure the amount of CO_2 eliminated in the entire agricultural process, including emissions due to the use of urea. Using a specific available impact assessment method, the Greenhouse Gas Protocol, in openLCA software, it was possible to calculate these emissions for each one of these processes. This method establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions (GHG PROTOCOL, 2020).

3. RESULTS

The results of the LCI analysis indicates that the agricultural phase has a fundamental role in potential environmental impacts of the production process. The emissions associated with the use of chemicals for soil correction and chemical fertilizers for fertilization stand out. It is known that nitrogen fertilizers emit gases that contribute to the greenhouse effect (LIU, 2020), in addition there is the fact that the LCI structure includes impacts of processes linked directly and indirectly to the final product (SILVEIRA, 2015). The following table shows the quantities of the main nitrogen emissions from these processes.

Table 1. Calculated nitrogen emissions from the systems.

Emissions	Amount (kg/ha)
N_2O	1.8
NH_3	13.48
NO_x	0.38
NO_3	248.59

With the system's modeling using the openLCA software, a series of results were obtained for the impact categories provided by impact assessment method GHG Protocol in the database. The impact categories that are related to carbon emissions are the fossil-based carbon, from fossil fuels; the biogenic carbon, from biogenic sources such as plants and trees; the carbon from land transformation and carbon uptake, CO_2 that is stored in plants and trees as they grow.

These data were organized into three tables, each one representing a different stage of the complete production process that is the focus of this study. Table 2 shows the results obtained for the agricultural stage of the production process. In this stage, the canola grains are produced and the flows are analyzed from the soil's preparation to receive the seeds to the harvest of the grains.

Table 2. Results obtained for the canola grain production process.

Impact categories	Result
Biogenic CO_2 eq	0.39640 kg CO_2 eq
CO_2 eq from land transformation	1.47653 kg CO_2 eq
CO_2 uptake	1.48237 kg CO_2 eq
Fossil CO_2 eq	3.05124 kg CO_2 eq

Table 3 shows the results achieved for the production stage of canola meal, one of the co-products of the process, obtained from the extraction phase, as shown previously in Fig. 2 (b).

Table 3. Results obtained for the canola bran production process.

Impact categories	Result
Biogenic CO_2 eq	0.09805 kg CO_2 eq
CO_2 eq from land transformation	3.43969 kg CO_2 eq
CO_2 uptake	2.43054 kg CO_2 eq
Fossil CO_2 eq	4.43400 kg CO_2 eq

Table 4 shows the results obtained for the canola oil production process, the other co-product obtained from the extraction phase.

Table 4. Results obtained for the canola oil production process.

Impact categories	Result
Biogenic CO_2 eq	0.18980 kg CO_2 eq

CO_2 eq from land transformation	6.05611 kg CO_2 eq
CO_2 uptake	4.28957 kg CO_2 eq
Fossil CO_2 eq	7.81301 kg CO_2 eq

Diesel is the fossil fuel used in all stages of the agricultural phase, its burning releases high amounts of carbon dioxide (CO_2) into the air. Despite this, the process that most contributed to the emission of fossil CO_2 was the production of canola oil. These results indicate that external and internal processes have an expressive contribution to environmental impacts, according to works previously presented (SILVEIRA, 2018). Another important preliminary data to note is the amount of CO_2 uptake, where the process that emits the most, is also the process that most absorbs carbon dioxide, the case of canola oil production. All analyzed processes in this study presented considerable amounts of CO_2 emissions.

4. CONCLUSION

The LCI analysis can help to identify critical processes associated with potential environmental impacts, this tool allows the visualization and identification in the production system of the critical and impactful points in the production chain. The results indicate that to reduce canola's potential environmental impacts to a bioenergy source more sustainable, it is important to reduce chemical fertilizers use and possibly introduce alternative energy sources through the processes.

Regarding the industrial phase, in the drying stages of the grains, extraction and degumming of the oil, firewood is used for the heat and steam generation, a fact that intends to prove the environmental relevance of the biomass usage for the energy generation in comparison to the burning of fossil fuels.

5. ACKNOWLEDGEMENTS

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7. RESPONSIBILITY NOTICE

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