Environmental and Economic assessment of sugarcane production systems in São Paulo State, Brazil

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Introduction

Sugarcane sector has experienced significant changes as a result of its expansion and new environmental standards aimed at extinguishing burning of sugarcane fields before harvest. These factors have encouraged increasing level of mechanization in sugarcane farming, mainly in the harvest operation. Recently, due to new working safety standards (NR 31) and shortage of manpower availability, sugarcane mechanized planting also is being introduced. All these changes generate economic and environmental impacts that must be evaluated for the identification of sustainability indicators of the sugarcane agricultural production for bioenergy purposes. This work aims at evaluating economic and environmental indicators of three scenarios (production systems) for sugarcane production in the São Paulo State, the main producer of sugarcane in Brazil. Scenario 1 represents the "classic" production system where the planting of sugarcane is semi-mechanized (which involves manual operations such as harvesting of seedlings, seedling distribution and chopping of stalks; and mechanical operations such as opening and closing furrow) and manual harvesting with the previous burning of the sugarcane residues. This production system has been abandoned in recent years, mainly due to a state bill that is controlling and systematically eliminating the practice of pre-harvesting burning in São Paulo State. Several production units are adopting mechanical harvesting, with significant changes in the production system. This practice was evaluated in Scenario 2 in this study. In this scenario planting is also semi-mechanized, but the harvest is done mechanically without pre-harvesting burning. Finally, Scenario 3 represents the most "modern" sugarcane production system since both the planting and harvesting are done mechanically, with effective decrease in labor cost.

Results and conclusions

Economic and environmental analyses were performed based on electronic spreadsheets detailing all operations used in each of the three scenarios. It allows characterization and quantification of all the inputs such as fertilizers, machinery, diesel, manpower, among others; and outputs such as products and emissions. All the information required to conduct this study was obtained by scientific, technical, electronic and personal communication, being organized in different scenarios after a critical analysis of its representativeness to the case study. Results were then used to identify the processes with most critical environmental and economic impacts and, therefore, pointed out as focus for further research on technological development to ensure sustainability of the sugarcane agricultural production system. In this study it was considered the sugarcane culture during 5 seasons considering the potential yield of each

harvest. The average total cost (considering 5 harvests) calculated in this work was R$ 38 per ton of sugarcane in Scenario 1; R$ 39 per ton of sugarcane in Scenario 2; and R$ 40 per ton of sugarcane in Scenario 3. It is possible to notice increasing production costs with increasing mechanization level. For example, manual operations in Scenario 1 corresponded to 28% of the total production cost, whereas in scenarios 2 and 3 these figures were only 5% and 2%, respectively. Therefore, there is no doubt that manual harvesting is the operation that requires more manpower (also overcoming the planting) since in Scenario 2 manual operations accounted for a significant smaller fraction of the total costs than in Scenario 1. On the other hand, mechanized operations costs represented approximately 40% of the total production costs in Scenario 1; 65% in Scenario 2; and 66% in Scenario 3. These values indicate that harvesting and loading are the operations that require greatest amount of economic resources between all the mechanized operations in the sugarcane production system. Regarding to the raw materials use, they accounted for 30% of the total production costs in Scenarios 1 and 2 and 35% in Scenario 3. This difference can be explained due to higher amount of sugarcane seedlings required in mechanized planting. This is because the quality of the seed stalks is severely affected due to damage caused by the mechanical operation, compromising the sugarcane bud. When using mechanical planting up to 10 more tons of seedlings are required per hectare to ensure a good number of plants per unit of area. This indicates the importance of more studies to improve quality of mechanized planting and to reduce costs of this operation. Environmental impact assessment results calculated using Life Cycle Analysis showed that options with higher level of mechanization (Scenarios 2 and 3) showed better results in the global warming and photochemical oxidation indicators in comparison to the scenario with manual planting and harvesting (Scenario 1). This is due to elimination of the pre-harvesting burning operation of sugarcane, which significantly reduces emissions of greenhouse gases (CO_2, N_2O and CH_4) in Scenarios 2 and 3. In other environmental impact indicators (abiotic depletion, acidification, eutrophication, ozone layer depletion and ecotoxicities) it was not possible to observe significant difference between Scenarios. However, Scenario 1 presented slightly better results than Scenarios with higher mechanization level (2 and 3) because lower inputs are required for manual harvesting and planting. Apparently, the gradual change presented in recent years by the sugarcane production system shows positive impacts on an environmental standpoint. However they can and should be maximized because there are many bottlenecks to be solved such as: reduce tillage mechanical operations, increase quality of seedlings in mechanical planting, reduction soil compaction, increase the amount of agricultural residues that are available be used in the industrial process for bioenergy production, among others. All these challenges are included in the scientific agenda of CTBE in order to maximize the sustainability of sugarcane production and industrialization in Brazil.

Keywords: Life Cycle Assessment; Production cost; Mechanization; Harvesting; Planting.

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