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Life Cycle Assessment for Apple Production in Traditional Orchard and Dwarf Orchard Systems in Japan

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Introduction

Agriculture and food sectors contribute to over 24% of all anthropogenic greenhouse gas emissions. Due to rapid population growth, global food demand has increased which lead to significant damage to the environment[1]. In this regard, a systemic change in the current agri-food system is needed to ensure safe and environmentally friendly. Life Cycle Assessment can provide fact-based analysis for clear-headed decisions[2]. The objective this study was to compare and evaluate environmental impacts of traditional and draft orchard systems for apple cultivation in Japan using LCA methodology.

Methodology

Life Cycle Assessment (LCA) methodology was performed by the guidelines and requirements of the ISO 14040 standard series[3,4]. A cradle-to-gate approach has been used as system boundaries in this study. The functional unit (FU) was defined as one kg of fresh apple as mass-based FU. The primary data was directly supplied by production manager from Apple Research Institute, Aomori prefecture, located in specific geographical position at 40°40'04.0"N 140°35'25.3"E and referred to apple harvested in 2023 production year. The study was modelled with SimaPro v9.5 using LIME2 impact assessment method and IDEA and Ecoinvent database.

Results and Discussion

The environmental impacts, referred to the FU, are showed in Table 1. The impact per (kg.year) of the draft orchard was lower than the one of the traditional orchard for almost all the examined impact categories except for eutrophication with similar values. In both orchard systems the greatest impacts were charged to the following categories: acidification, global warming potential, and biological toxicity. Furthermore, a detailed analysis of the material and inputs showed that a significant share in the overall environmental impacts is due to the use of pesticides and fertilizers. Therefore, the main improvement actions adopted by the apple growers to reduce environmental impacts should be focused on minimizing the use of chemical inputs such as pesticides and fertilizers as much as possible.

Table 1. Characterization results for main impact category for 1 kg of fresh apple at the farm gate.

Impact category	Unit	TOS	DOS
Climate change	kg-CO_2eq	0.175	0.160
Acidification	kg-SO_2eq	1.31	1.22×10^{-4}
Toxic chemicals (cancer)	kg-C_6H_6eq	2.38×10^{-4}	2.32×10^{-4}
Acidification	kg-SO_2eq	1.31×10^{-4}	1.22×10^{-4}
Aquatic toxicity	kg-C_6H_6eq	2.25×10^{-3}	2.10×10^{-3}
Biological toxicity	kg-C_6H_6eq	0.011	0.010
Land use (Occup;)	m^2a	3.92×10^{-3}	3.87×10^{-3}

[a] TOS: Traditional Orchard System, [b] DOS: Draft Orchard System

References

1) Van der Werf, H.M.G., Garnett, T., Corson, M.S., Hayashi, K., Cederberg, C., 2014. Towards eco-efficient agriculture and food systems: theory praxis and future challenges. J. Clean. Prod. 73, 1-9.

2) Williams E., Schumacher L., 2021. Agri-food: how LCA may play a role in the future food system. PRé Sustainability Platform.

3) ISO, 2021a. ISO 14040 Environmental management - life cycle assessment: Principles and framework, Geneva, Switzerland.

4) ISO, 2021b. ISO 14044 Environmental Management - Life Cycle Assessment: Requirements and Guidelines, Geneva, Switzerland.

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