Comparative analysis of two olive grove production systems using Life Cycle Assessment

Rafael Linares-Burgos[*1], Antonio López-Uceda[2], Adela P. Galvín, Cristina Martínez-Ruedas[4]

[1]Department of Rural Engineering, Civil Constructions and Engineering Projects, University of Córdoba, Ed. Leonardo Da Vinci - Campus de Rabanales, 14071 Córdoba, Spain; g82libur@uco.es (Rafael Linares); apgalvin@uco.es (Adela P. Galvín)
[2] Department of Mechanics, University of Córdoba, Ed. Leonardo Da Vinci - Campus de Rabanales, 14071 Córdoba, Spain; p62louca@uco.es (Antonio López)
[4]Department of Electronic and Computer Engineering, University of Córdoba, Ed. Leonardo Da Vinci - Campus de Rabanales, 14071 Córdoba, Spain; z42maruc@uco.es (Cristina Martínez)

Presenting author email: g82libur@uco.es

Abstract

The agricultural phase has been consistently identified as the most environmentally impactful stage in the olive oil life cycle, mainly due to fertilization, irrigation, pesticide application, and land occupation. In this context, the present study aims to compare the environmental performance of two different olive orchard plots through a Life Cycle Assessment (LCA) approach in order to identify the main impact drivers and evaluate potential sustainability improvements at farm level.

A cradle-to-gate system boundary was defined, including all agricultural operations from soil preparation and cultivation to olive harvesting and transport to the mill. The functional unit was established as 1 kg of olives produced. Primary data were collected directly from both plots, considering differences in agronomic management practices, input intensity, irrigation strategies, and mechanization level. The LCA was conducted following ISO 14040 and ISO 14044 standards, and environmental impacts were calculated using the IMPACT 2002+ methodology. The selected impact categories included Global Warming Potential (GWP), Land Occupation (LO), Abiotic Depletion (fossil fuels and elements), Water Consumption, Aquatic Eutrophication, Ecotoxicity (terrestrial and aquatic), Ozone Layer Depletion, and Human Toxicity.

The comparative analysis allows the identification of the main environmental hotspots associated with each cultivation system and quantifies how variations in agricultural management influence impact categories related to climate change, resource depletion, and ecosystem quality. Preliminary results indicate that differences in fertilization strategies, irrigation intensity, and energy use significantly affect GWP, water consumption, and non-renewable energy demand.

This study highlights the critical role of agricultural practices in determining the overall sustainability of olive oil production and demonstrates the usefulness of LCA as a decision-support tool for improving environmental performance at farm level. The results provide a scientific basis for optimizing olive cultivation systems under sustainability criteria aligned with the United Nations 2030 Agenda goals.

Keywords: *Agro-industrial sustainability, Environmental impact assessment, Lifecycle assessment, circular economy, digital industry, olive oil production*