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International conference on Life Cycle Assessment
as reference methodology for assessing supply chains
and supporting global sustainability challenges

LCA FOR "FEEDING THE PLANET AND ENERGY FOR LIFE"

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Edited by Simona Scalbi, Arianna Dominici Loprieno, Paola Sposato

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Life Cycle Assessment of organic apple supply chain in the North of Italy

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1. Abstract

The goal of the study is the assessment of the energy and environmental impacts of 1 ton of organic apples cultivated in the North of Italy, by applying the Life Cycle Assessment methodology. The authors examined the supply chain of apples, by including the supply of raw materials and energy sources, and the farming step. In addition, an assessment of apple distribution to the final users was made.

The results show that a relevant share of the total impacts is caused by the transport to the final users, assuming that the product is distributed on local, national and international markets. A detailed analysis of the farming step shows that a significant share in the overall energy and environmental impacts is due to the use of insecticides and to the consumption of diesel for agricultural machines.

2. Introduction

Agriculture is one of the main sectors affecting the environment through its direct impacts on land use and ecosystems, and on global and regional cycles of carbon, nutrients and water. At global level, agriculture contributes to climate change through emission of greenhouse gases and reduction of carbon storage in vegetation and soil. Locally, agriculture reduces biodiversity and affects natural habitats through land conversion, eutrophication, chemical product inputs, irrigation, etc [1].

The environmental pressure from agriculture can be reduced with organic farming, which represents a key factor in the agricultural sector, due to the added value of its products, to the socio-economic benefits for the producers and to the positive effects on the environment and on the human health.

To calculate the burdens of the whole supply chain of organic products and to compare them with the impacts of conventional products becomes significant for assessing the effective energy and environmental advantages due to the cultivation of these products instead of non-organic ones.

3. Case study: LCA of organic apples in the North of Italy

The present study was developed within the project "BIOQUALIA – Nutritional and organoleptic quality and environmental impact of organic productions", funded by the Italian Ministry of Agriculture, Food and Forestry Policies.

3.1 Goal and scope definition

The goal of the study is the assessment of the energy use and environmental impacts of 1 ton of organic apples (selected as functional unit) cultivated in the North of Italy. The study was carried out applying the

Life Cycle Assessment (LCA) methodology as regulated by the international standards of series ISO 14040 [2, 3].

The authors examined the supply chain of apples, which includes the supply of raw materials and energy sources, and the cultivation step. Particular attention was paid on key issues, such as energy consumption, water use and insecticide use in the farming activities. In detail, the following steps of the cultivation process of apples were examined: machine use, pruning, land management, fertilization, irrigation, thinning, antiparasitic treatment, replanting, harvest and transfer to cooperatives, and post-harvest defense. Further details on each step of the cultivation process can be found in [4]. In addition, an assessment of raw material transport and distribution of apples to the final users was made, assuming that the product is distributed on local (10%), national (40%) and international markets (50%).

3.2 Life Cycle Inventory and Life Cycle Impact Assessment

The inventory analysis was carried out to quantify the environmentally significant inputs and outputs of the examined system, by means of a mass and energy balance of the selected functional unit.

The main energy and material inputs and outputs of the apple supply chain were collected from local investigations. Eco-profiles of energy sources, materials and transports were from international environmental databases [5, 6].

The inventory data, in terms of resource consumption, air, water and soil emissions, and waste production, were elaborated and synthesized by using the following impact categories: global energy requirement (GER), global warming potential (GWP), ozone depletion potential (ODP), acidification potential (AP), eutrophication potential (EP), photochemical ozone creation potential (POCP).

The characterization factors for GER were from the Cumulative Energy Demand [6] method, that enables the estimation of the consumption of renewable (biomass, wind, solar, geothermal, water) and non-renewable (fossil, nuclear) energy sources. The other environmental characterization factors were from the EPD 2013 impact assessment method [7].

The obtained results are detailed in the following. GER was 6.9 GJ/ton, of which 98.5% is represented by non-renewble energy sources. The transport of apples to the final users is responsible of about 70.9% of the total energy impact, and the remaining 29.1% is due to the cultivation (28.9%) and the transport of raw materials (0.2%).

A detailed analysis of the cultivation step (Fig. 1) showed that the main impacts are caused during replanting (23.7%), harvest and transfer to cooperatives (20.2%), irrigation (19.4%), and antiparasitic treatment (18.2%). The other steps give a contribution variable from 1.1% to 6.7%.

The environmental impacts, referred to the functional unit, are the following: GWP 425.45 kg CO_{2eq}, ODP 7.38E-05 kg CFC-11_{eq}, AP 2.30 kg SO_{2eq}, EP 0.76 kg $PO_4^{3-}{}_{eq}$, POCP 0.57 kg C_2H_{4eq}.

The percentage incidence of each examined step on the total impact, mainly caused by the transport of apples to the final users, is showed in Table 1.

Referring to the cultivation, GWP, POCP and AP are mainly caused by replanting step, which contributes to the above impacts for about 24.1%, 22.5% and 21.0%, respectively. The machine management is the main responsible of the impact on ODP (52.6% of the total), while the fertilization step causes about 43.6% of the impact on AP.

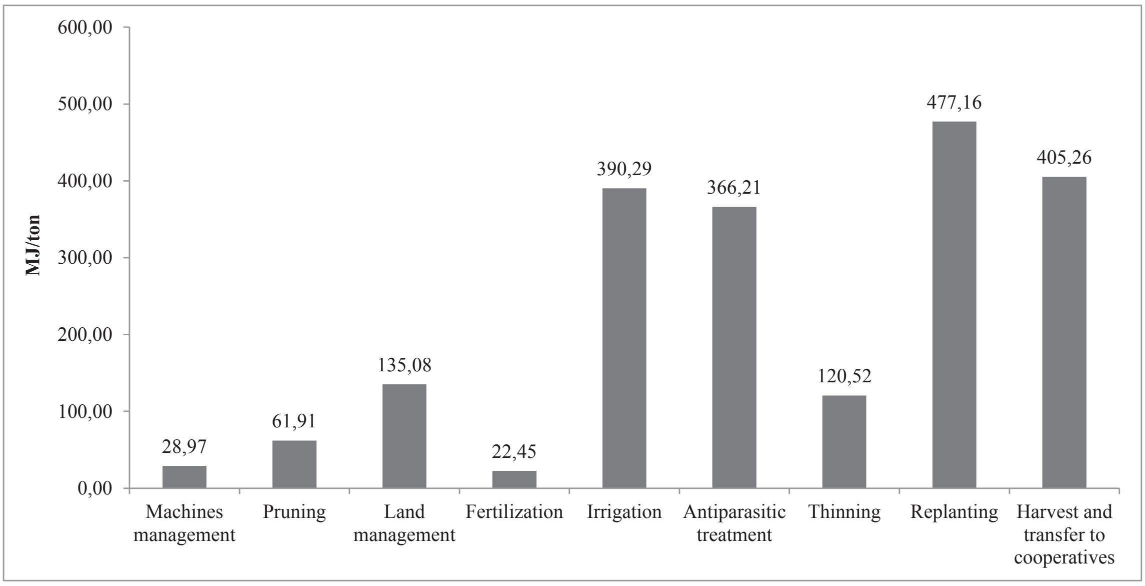

Figure 1: GER of the cultivation step

	Cultivation	Transport of raw materials	Transport of apples to final users	Total
GWP (kg CO_{2eq})	133,42	0,81	291,22	425,45
ODP (kg CFC-11_{eq})	3,20E-05	1,03E-07	4,17E-05	7,38E-05
POCP (kg C_2H_{4eq})	0,18	0,001	0,39	0,57
AP (kg SO_{2eq})	0,87	0,003	1,43	2,30
EP (kg $PO_4^{3-}{}_{eq}$)	0,38	0,00	0,38	0,76

Table 1: Environmental impacts: incidence of each examined step

A preliminary comparison between the obtained results and the impacts of conventional apples [8, 9, 10] was carried out, even if a reliable comparison should be made by using data coming from the same geographic area, considering that different climate and cultivation techniques can significantly influence the final results. The comparison showed that, generally, there are not significant differences between organic and conventional apples in terms of energy and environmental impacts. However, as demonstrated by the project BIOQUALIA of which this research is part, organic apples have superior nutritional and organoleptic characteristics than conventional ones.

4. Conclusion

The LCA methodology can support the development of studies that aim at reducing energy and environmental impacts throughout the supply chain of products and can contribute to the application of sustainable production and consumption strategies [11, 12].

The study focused on the analysis of impacts of organic apples. The application of LCA allowed assessing the incidence of each life cycle step of apples supply chain on the overall impacts and selecting the “hot spots” of the examined system, by the identification of steps and processes responsible of the largest impacts. The results showed that a relevant share of the total impacts (variable from about 51% to about 71%) was caused by the transport of apples to the final users, and in particular to the distribution to international markets. A detailed analysis of the farming step was carried out, showing that a significant share in the overall energy and environmental impacts is due to the use of insecticides and to the consumption of diesel for agricultural machines.

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