Journal of Cleaner Production 112 (2016) 32–38

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Life cycle assessment of carnation production in Greece

Konstadinos Abeliotis*, Sofia-Anna Barla, Vassilis Detsis, George Malindretos

School of Environment, Geography and Applied Economics, El. Venizelou 70, 17676 Kallithea, Greece

ARTICLE INFO

Article history:
Received 9 December 2014
Received in revised form
1 June 2015
Accepted 5 June 2015
Available online 17 June 2015

Keywords:
Carnation
Cut flowers
Life cycle assessment
Greece

ABSTRACT

Cut flowers represent a globalised economic sector that is associated with various environmental impacts. The aim of this research is the presentation of the results of the application of life cycle assessment in the environmental assessment of the greenhouse farm cultivation of carnations (*Dianthus caryophyllus* L.) in Greece. The scope of the present research included the cultivation of carnations in a greenhouse in the eastern part of the Peloponnese region in Greece. Inventory was based on the actual field operations for the cultivation of carnations in greenhouses. The impact assessment method used was CML 2 baseline 2000. The results indicate that the major environmental impact is caused by the use of electricity for the refrigerated preservation of the cut carnations.

1. Introduction

Cut flowers are parts of plants, characteristically including the blooms and some attached plant material, but not including roots and soil. The three principal types of fresh cut flowers cultivated around the world are roses, carnations, and chrysanthemums which represent more than 50% of the total global market.

The European Union's (EU) flowers production share in global production is estimated at 44%, followed by China (13%), USA (12%), and Japan (9%); the Netherlands alone participates in one third of the EU27 production, followed by 13% in Italy, 12% in France and 12% in Denmark and in Spain and 5% in the UK (Eurostat, 2012). According to the International Trade Center (2014) global cut flowers exports have grown over the last five years by more than 10% and the annual consumption ranges from US$ 7–9 billion. The EU is the world's largest consumer of cut flowers, consuming almost 70% of global production (Mather, 2008).

However, to meet the increasing global demand, production has gradually moved from countries that have traditionally been consumers and growers, such as the Netherlands, to other relatively new producing countries such as Israel, Colombia, Ecuador, Kenya, Ethiopia, Malaysia, etc. Although Netherlands is still the world's largest cut flower export nation, its share is diminishing. On the other hand, the share of developing country cut flower exports to the EU has increased significantly in the last twenty years, facilitated by innovations in logistics which allow the rapid transport of fragile flowers from producing countries to consuming ones. Thus, at the period 2003–2013 the share of the Netherlands' exports decreased from 58% to 52%, while in 2013 Kenya reached 7% (3% in 2003), Ecuador 9% (6% in 2003), Ethiopia 2% (0.5% in 2013), etc. (UN Comtrade, 2014).

Imports to the EU are mainly routed to the UK, the Netherlands and Germany, originating from Colombia, Kenya, Turkey and Morocco (Moyal-Ben Zvi and Vainstein, 2007; Rikken, 2010).

In Greece, floriculture occupies an area of 1,300 hectares (ha.), half of them being covered, i.e. greenhouses. Cut flower cultivations cover 550 ha, pot flowers 120 ha and finally gardening flower cultivations cover more than 220 ha. The net flower market in Greece is estimated at €300 millions, 70% of which is attributed to the local production, while the rest is the share of imports. Exports of flowers from Greece are very low, representing 10–15% of the imports. In addition, the ratio of the value of Greek floriculture production to total food production has shown an increasing trend during the last thirty years period, according to the Hellenic Statistical Authority report (2012), while the ratio of the farm production value to GDP has shown falling trend during the same period. These two ratios in combination show a relatively positive development trend of the floriculture industry, at a time of a negative trend of the total food industry in Greece.

Carnation (*Dianthus caryophyllus* L.) is a member of Caryophyllaceae family and a native of the Mediterranean area. This plant is one of the world's most popular, economic and important

* Corresponding author.
E-mail addresses: kabeli@hua.gr (K. Abeliotis), sa_barla@yahoo.gr (S.-A. Barla), detsis@hua.gr (V. Detsis), gmal@hua.gr (G. Malindretos).

http://dx.doi.org/10.1016/j.jclepro.2015.06.018
0959-6526/

cut flowers due to perpetual flowering and the presence of new single- and multi-colour cultivars (Whealy, 1992).

The main carnation producing countries in the E.U. are the Netherlands, France, Italy and Spain. However despite the aforementioned cultivation in the E.U, countries, in the whole E.U. market, carnations represent 20% of the cut flowers imports, second only to roses. Other countries in which carnations are cultivated are Turkey, U.S.A., Colombia, Kenya, Australia and Mexico. In Greece, carnations are cultivated from 50 years. Today, they represent the most important floriculture cut flower product of Greece, covering an area of 150 ha. Sixty percent of them are covered by greenhouses. Crete is the major producing area in Greece. In the southern part of Greece, cultivation of carnations is taking place in non heated greenhouses, while in northern Greece, carnation greenhouses are heated. Carnation cultivation can also take place in uncovered areas; in this case, wind protection of the plants is required.

The environmental impacts of cut flowers during their life cycle are mainly associated with their cultivation (Russo et al., 2008b) but also with their transportation, mainly by airplane, from the countries of production to the places of final distribution and consumption (Sahle and Potting, 2013). Life cycle assessment (LCA) has become a popular tool for the objective and transparent quantification and assessment of environmental burdens of products and services in agriculture (Cerutti et al., 2014). Thus, the aim of the present research is the presentation of the results of the application of LCA in the assessment of the greenhouse farm cultivation of carnations in Greece. Since cut flowers have high requirements for their post-harvest preservation we were especially interested in the balance between environmental impacts of processes taking place pre- and post-harvest. While cultivation practices have attracted significant attention with respect to their environmental impact post-harvest processes may have even higher impacts, especially in the case of sensitive products (Gunady et al., 2012; Girgenti et al., 2014).

The paper at first reviews the application of life cycle assessment in floriculture; then the functional unit and the major cultivation operations and modeling assumptions of the present study are presented that the compilation of the inventory table was based on; finally the impact assessment results are presented, discussed and compared to the relevant results of earlier studies.

2. Methods

2.1. Life cycle assessment in floriculture

Focusing in floriculture, very few LCA studies appear in the international literature. The group lead by Russo et al. (2008a) and (2008b) analysed, via the implication of LCA, 22 greenhouse floriculture farms in the southern district of Bari, which represents 20% of the flowers cultivation of Italy. The authors studied both the cultivation of cut roses (in hydroponic cultivation and in soil) and cyclamens in pots. Mainly fuel for heating, followed by pesticides and fertilizers were the causes of the environmental impacts for the cut roses' stems while production of baby plants for transplanting and their packaging were the main causes for environmental damage for the production of cyclamens in pots (Russo and De Lucia Zeller, 2008). The environmental LCA results of Sahle and Potting (2013) clearly indicate that the intensive use of fertilizers is the main contributor to the environmental impact of Ethiopian rose cultivation, followed by the emissions from the use of pesticides and insecticides (air transport was not considered in their study). Michael (2011) concludes that the cultivation of Australian waxflowers has a relatively low environmental impact; however the main challenge that the Australian wax industry has to address is the emissions from air transport resulting from the export of the cut flowers. Recently, Beccaro et al. (2014) examined the methodological issues related to environmental impacts of nursery plant production in Italy.

Also, a social LCA study appears in the literature referring to floriculture. Franze and Ciroth (2011) compare cut roses form Ecuador and the Netherlands. The authors, focusing in the environmental impact, they conclude that it is environmentally friendlier to import roses from Ecuador, particularly in winter when heating and lighting is required in European conditions.

2.2. Description of the case study

The current LCA deals with the *Dianthus caryophyllus* carnation. Based on the ISO14044 standard (2006), there are four steps in an LCA study: the goal and scope definition, the inventory analysis, the impact assessment and the interpretation. In the following the goal and scope are presented and the system under study is described along with other essential aspects of it, namely the functional unit and the assumptions made where necessary.

2.2.1. Goal and scope

The goal of this research is the life cycle assessment of the production of carnations in greenhouses in Greece. The scope of the study includes the structure of the greenhouse, the cultivation of the carnations, their preservation, and their transportation to Athens. Fig. 1 depicts the exact system boundary. Life cycle stages depicted in grey-shade were not taken into account. Regarding the carbon balance of the plants, its biogenic part has not been accounted for, since this was outside the scope of this study.

The impact assessment method used was CML 2000 developed by the Centre of Environmental Science of Leiden University (Pré Consultants, 2003). The impact category indicators, included in the CML 2000 ready-made method, considered in our assessment, were: abiotic depletion factor (ADF), stratospheric ozone depletion potential (ODP), global warming potential for time horizon 100 years (GWP100), Marine aquatic ecotoxicity potential (MAETP), fresh water aquatic ecotoxicity potential (FAETP), terrestrial ecotoxicity potential (TEP), human toxicity potential (HTP), photochemical ozone creation potential (POCP), acidification potential (AP), and eutrophication potential (EP). These impact categories have been successfully applied recently (Abeliotis et al., 2013; Khoshnevisan et al., 2013) in the field of agricultural LCA.

2.2.2. Functional unit

The concept of the functional unit is a key one in LCA, facilitating the comparison of alternative products and services (ISO 14044, 2006). In the present study, the functional unit is defined as the annual yield of carnations per ha in the local geographical and climatic condition of the Peloponissos region in Greece. This unit corresponds to 1.5 million stems of carnations.

2.2.3. Data collection

For the assembly of the inventory, the foreground system considered was based on the actual field operations for the cultivation of carnations in greenhouses. Data for the study was collected from a combination of direct survey, interview with a single carnations' producer, located in the eastern coast of Peloponesse in southern Greece, and literature sources. Data associated with the effects produced by the inputs in the background system (production of plant protection chemicals and fertilisers, electricity generation and transportation) were derived from the SimaPro 5.1 database and literature sources.