Environmental footprint of roses: Summary of the representative product study

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Introduction

This document is a summary of a representative product (RP) study carried out in the context of the development of a methodology for calculating the environmental footprints of horticultural products, according to the HortiFootprint category rules (HFCR; see Helmes et al., 2020). The development of the HFCR was initiated by Royal FloraHolland, Dutch Fresh Produce Centre and Wageningen Economic Research, with co-financing from the Dutch Fund for Horticulture & Propagation Materials, ABN AMRO Bank N.V., the Dutch sector organisation for greenhouse horticulture (Glastuinbouw Nederland), MPS, Rabobank, Foundation Benefits of Nature and in co-production with experts from Blonk Consultants and PRé Sustainability.

This is one of the six studies on horticultural representative products that have been selected based on a wide and economically relevant variety of applied technologies and origins of productions. These are:

- Roses (perennial plant yielding flower stems, grown in soil in a greenhouse, with and without air transport);
- Phalaenopsis (ornamental plant cultivated in two stages, in substrate and in greenhouse);
- Tulip bulbs (annual crop in soil, grown without greenhouse protection, with ornamental function);
- Tomatoes (annual vegetable cultivated in greenhouse, on substrate);
- Bananas (tropical perennial fruit with variability in energy-consuming global transport);
- Apples (temperate perennial fruit with variability in energy-consuming storage and global transport).

This summary is prepared on the basis of an RP study for assessing the environmental footprint of the complete life cycle of roses from greenhouses in the Netherlands, which was completed in 2018.

Goal & scope

The representative product under study is roses from greenhouses in the Netherlands. The objectives of this study are:

- To identify the most relevant impact categories, life cycle stages and processes;
- To determine the data (quality) requirements;
- To support the development of the HFCR; an earlier draft of the HFCR was tested to check the draft HFCR for completeness and clarity, and to check the feasibility of completing a study in accordance with the draft HFCR

This fact sheet summarises the representative product (RP) study for roses, produced in a Dutch greenhouse with combined heat and power (CHP) system, transported across the main countries of export. The functional unit (FU) is one stem of 70 cm-long roses at commercial grade.

The system includes a greenhouse structure (built from glass, steel, aluminium, concrete, etc.) with a combined heat and power unit with a flue gas treatment to provide heat, electricity and purified carbon dioxide. The number of roses per unit area was derived from primary data.

The rose bushes are grown by planting propagation material in soil and the crop is then managed with fertilisers, water and pesticides. Surplus electricity produced in the CHP is supplied to the grid. After harvest the roses are refrigerated for one day and distributed to retail shops. The use of roses was also accounted together with their disposal.

Data collection and modelling

The following key methodological choices and assumptions were made:

- The cultivation, combined heat and power, and carbon dioxide purification processes were divided into different unit processes.
- For the co-production of heat and electricity, energy allocation was applied.
- The heat production efficiency was assumed at 48% and the electricity production efficiency 40% (Van der Velden and Smit, 2017).
- The emissions from burning natural gas in the CHP system were derived from IPCC (Gomez et al., 2007) for CO_2 and N_2O, from Plomp & Kroon (2013) for CH_4, and from the European Environmental Agency (EEA, 2016) for NO_x, CO, non-methane volatile organic compounds, SO_2 and particulate matter.
- Industrial CO_2 production was modelled according to Xuezhong and Hägg (2014), Veneman et al., (2013), Frischknecht (1999) and OCAP (2018).
- The technical lifetime of the capital goods for cultivation (greenhouse structure) is assumed to be 15 years.
- The rose bush will last 10 years; after that the soil is tilled with a petrol rotavator with a power of 3.96 kW. The residues are composted.
- The roses are packed in bunches of 10 roses covered in polypropylene film, while 9 bunches are on each layer of aluminium cart, composed of three separate layers, which is used to store the roses.
- The transport of the roses is accounted on the basis of the export market for flowers in the Netherlands, as it was assumed that roses will be grown in Dutch conditions. Distances were estimated on average for each export country using Google maps (Google, 2019).
- The retail phase was based on statistical data for energy consumptions. However, water consumption and plastic wrapping was accounted for with the assumptions that the flowers are sold in the same bucket used in the transport but filled with new water, and the plastic wrap is changed for delivery to the customer.
- In the use of a glass vase of 10 cm diameter and a height of 15 cm is used. The vase is filled to a height of 7.5 cm with water.
- Some waste is sent to a nearby waste treatment facility while biowaste is sent to composting.
- Field N_2O, nitrate and ammonia emissions were accounted for according the IPCC Tier 2 methodology (Vonk et al., 2018).

- No accounting is carried out for soil C in agreement with the PEFCR guidance, despite research highlighting its importance (Brandão et al., 2013; Garrigues et al., 2012; Goglio et al., 2015, 2017).

Foreground data was collected as averaged primary data from rose-growing operations in the Netherlands as compiled by Benefits of Nature, and augmented with data from literature (see the assumptions above and ASABE, 2011). For storage, retail and the use stages, datasets were created using default data for these, processed using the PEFCR guidance documentation (EC, 2018). The end of life was modelled using details from Annex C from the same document.

For the background data, ecoinvent version 3.4 cut-off was used (Wernet et al., 2016) as well as Agri-footprint 4.0 (economic, see Agri-footprint 2018 a,b). The EF Life Cycle Inventory (LCI) database could not be used, because the original study was not part of an official PEF pilot by the European Commission, as it was conducted before the current transition phase. The conclusions in this study and the aims this study can be used for have been drafted in such a way to ensure validity (see disclaimer).The modelling was done in SimaPro version 8.5.2, following the PEF rules at that time (EC, 2018). The impact assessment was done using the EF impact assessment model version 2.0.

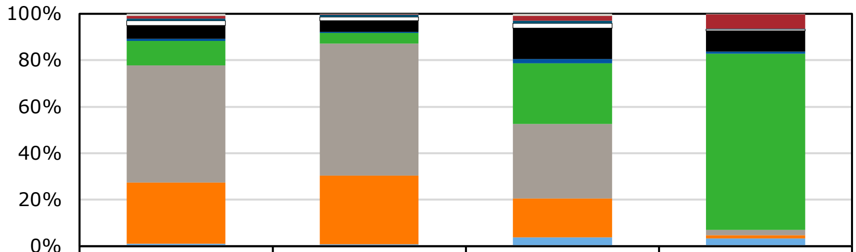
Most relevant impact categories, life cycle stages and processes

The **most relevant impact categories**, which contribute cumulatively to at least 80% of the normalised and weighted life cycle results of this study, are:

- Climate change;
- Resource use, energy carriers;
- Terrestrial and freshwater acidification.

The **most relevant life cycle stages** of the studied rose plant are cultivation (which includes capital goods, energy production, carbon dioxide and other activities) and transport.

Contribution of the life cycle stages to the most relevant impact categories



	Climate change	Resource use, energy carriers	Acidification terrestrial and freshwater	Ecotoxicity freshwater
End-of-life	1%	0%	1%	0%
Use	1%	0%	2%	6%
Retail	1%	1%	1%	0%
Storage	2.0%	2%	2%	1%
Distribution	6%	5%	13%	9%
Packaging	0.8%	1%	2%	1%
Cultivation - Other processes	11%	4%	26%	76%
Cultivation - Heating	50%	57%	32%	2%
Cultivation - Electricity	26%	30%	17%	1%
Cultivation - Capital Goods	1%	1%	4%	3%

Figure 1 *Contribution of the life cycle stages of rose cultivation to the relevant impact categories*

Freshwater ecotoxicity was not included in the weighted results, but considered as relevant for inclusion in this RP study due to the perceived importance of the environmental impact of pesticides.

Table 1 shows the contribution of the rose life cycle stages to the relevant impact categories with additional detail for the cultivation stage.

Table 1 *The most relevant processes contributing in total at least 80% to the impact of one or more relevant impact categories*

	Climate change	Resource energy	Acidification	Ecotoxicity	Life cycle stage
Heat from CHP	42%	-	19%	-	Cultivation
Electricity from CHP	22%	-	10%	-	Cultivation
Natural gas production	12%	86%	19%	-	Cultivation
Emissions during cultivation	4%	-	9%	-	Cultivation
Biowaste treatment	-	-	8%	-	Cultivation
Road transport	-	-	7%	8%	Distribution
Air transport	-	-	6%	-	Distribution
Glass greenhouse	-	-	3%	-	Cultivation
Roses pesticide use	-	-	-	69%	Cultivation
Municipal waste treatment	-	-	-	6%	Cultivation
Remaining processes	20%	14%	19%	16%	n/a

Overall appreciation of the uncertainties of the results

The following factors have the most influence on uncertainty:

- The electricity and heat production efficiencies in the CHP system, the lifetime of the geothermal heat production capital goods and the input data for producing purified carbon dioxide have a major effect on the climate change and resource use, and energy carriers impact categories.
- The elementary flow data of the background database and the assumptions on acidifying (and particulates forming) emissions during cultivation and the related elementary flow data of the background databases have a major effect on the acidification terrestrial and freshwater impact category.
- The metal emissions data of the background database, and the assumptions how much of the applied pesticides are emitted to the different environmental compartments have a major effect on the ecotoxicity freshwater impact category.

The sensitive foreground data were estimated based on several sources, which may not always be representative for common practice. Therefore, they need to be critically revised if they will be used as defaults in case no accurate activity data are available. For the purpose of the current study, all assumptions and data estimations are considered adequate.

Data quality requirements

This study also aimed at identifying the data collection and data quality requirements to ensure robust and high-quality results for similar horticultural products. The requirements determined on the basis of this study are displayed in Table 2.

Table 2 *Data quality requirements (DQR) for the different life cycle stages for roses*

Life cycle stage	Current DQR	Data quality requirement (DQR score)
Cultivation	Amounts of inputs and elementary flows	≤1.6: Very good to excellent quality
Post-harvest handling	No post-harvest handling	Not applicable
Packaging	Generic data allowed	≤3.0: Good quality
Distribution	Distance and transport mode	≤1.6: Very good to excellent quality
Storage	Generic data allowed	≤3.0: Good quality
Retail	Generic data allowed	≤3.0: Good quality
Use	Generic data allowed	≤3.0: Good quality
End of life	Percentages and types of waste treatment, generic data allowed	≤3.0: Good quality
Inputs of the processes above and waste treatment processes	Generic data allowed	≤3.0: Good quality

Disclaimer

The RP study is NOT intended to make statements about the product group impacts as such, nor is it intended to be used in the context of comparison or for comparative assertions to be disclosed to the public. The results can be used to see where potential hotspots are by looking at the most relevant impact categories, life cycle stages, processes and elementary flows.

In practice, there is a large variety in greenhouse production of roses in respect to how energy is produced, and what sources of energy and purified carbon dioxide, and in what quantities, they are used. In many cases, a mix of different sources are used and the quantities will vary year by year due to weather conditions and economic developments. So, the absolute results of the current cases cannot be regarded as representative of the large variety in practice, but it is expected that the general conclusions on the hotspots and the resulting data quality requirements will apply to heated and protected production in European temperate climate zones.

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