Environmental footprint of bananas: 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, the HortiFootprint category rules (HFCR), (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 bananas, which was completed in 2019.

Goal & scope

The representative product under study is bananas. 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.

The system boundaries of the study include the cultivation of the bananas, packaging, land and maritime transport, ripening, distribution, retail and consumption. After planting the banana shoots, the bananas are harvested for several years. The conventional crop management is typical for the large amounts of chemical fertiliser use, aerial spraying of pesticides, surface irrigation and covering banana bunches with plastic covers to protect from pests. After harvest the bananas are rinsed, cut, wrapped in plastic, packed in carton boxes and placed on pallets. The loaded pallets are transported in cooled containers (14°C) to the storage and ripening station in the Netherlands. When ripened they go to the distribution centre, retail and finally the consumer. The packaging and excess organic material (including the peelings) are treated at disposal.

Data collection and modelling

Foreground data was collected from literature; data was used from several peer-reviewed LCA studies. For the field phase, data from the FAO was also used (FAO, 2018). For storage, retail and the use stage, datasets were created using default data for these, processed using the PEFCR guidance documentation. 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). The EF Life Cycle Inventory (LCI) database could not be used, because the current study is not officially approved by the European Commission yet. The modelling was done in SimaPro version 8.5.2, following the PEF rules at that time (European Commission, 2018). The impact assessment was done using the EF impact assessment model version 2.0.

Given the goal and scope of the study, the aim was to use world average data as much as possible. Therefore generic FAO data was used for yield per ha, fertiliser use and lifetime of banana plants. The yield however can vary substantially, and is also highly dependent on local conditions, but also on other variables like fertiliser use. In some instances, specific data had to be used because generic data was not available – this was the case for the use of pesticides. For the modelling of the water use and emissions from irrigation however country specific water flows from Ecuador {EC} were used because the intention was to study the growth of bananas in a major producing country.

Environmental footprint impact assessment results

Table 1 shows the characterised results of the life cycle of 1 kg bananas.

Table 1 *Characterised banana life cycle* results (Note: more information about indicators and units can be found in [4])*

Impact category	Unit	Total	Cultivation	Post-harvest handling	Packaging	Distribution	Storage	Retail	End of life
Climate change	kg CO_2 eq	9.3E-01	3.8E-01	8.4E-03	1.0E-01	4.1E-01	4.7E-03	1.6E-02	2.1E-02
Ozone depletion	kg CFC-11 eq	1.3E-07	2.8E-08	2.7E-10	9.0E-09	8.2E-08	7.6E-09	8.7E-10	-2.4E-10
Ionising radiation	kBq U-235 eq	4.9E-02	1.2E-02	3.0E-04	5.3E-03	3.1E-02	8.9E-04	1.2E-03	-1.4E-03
Photochemical ozone formation	kg NMVOC eq	6.1E-03	1.2E-03	3.2E-05	3.1E-04	4.6E-03	7.9E-06	2.2E-05	-6.0E-05
Respiratory inorganics	disease incidents	4.9E-08	3.5E-08	3.5E-10	4.9E-09	1.6E-08	7.0E-11	1.5E-09	-8.2E-09
Non-cancer human health effects	CTUh	1.4E-07	9.4E-08	2.9E-10	1.9E-08	3.3E-08	3.7E-10	9.2E-10	-2.6E-09
Cancer human health effects	CTUh	1.2E-08	6.3E-09	9.0E-11	1.1E-09	3.81E-09	2.8E-11	1.6E-10	-3.2E-11
Terrestrial and freshwater acidification	mol H^+ eq	1.2E-02	4.5E-03	3.8E-05	4.3E-04	5.7E-03	1.7E-05	3.0E-04	5.4E-04
Freshwater eutrophication	kg P eq	1.8E-04	8.5E-05	1.0E-06	4.1E-05	5.2E-05	1.7E-06	4.1E-06	-9.5E-06
Marine eutrophication	kg N eq	2.2E-03	4.4E-04	6.6E-06	1.5E-04	1.6E-03	2.4E-06	1.7E-05	2.2E-05
Terrestrial eutrophication	mol N eq	3.9E-02	1.7E-02	7.1E-05	1.2E-03	1.7E-02	3.0E-05	1.3E-03	2.9E-03
Freshwater ecotoxicity	CTUe	1.7E+00	1.1E+00	1.2E-01	1.1E-01	3.9E-01	1.2E-03	3.5E-03	5.0E-03
Land use	Pt	3.8E+01	3.6E+01	5.8E-02	1.5E+01	2.3E+00	1.7E-02	1.6E-01	-1.6E+01
Water scarcity	m3 depriv.	1.6E+00	1.6E+00	4.3E-03	2.0E-02	4.0E-02	7.6E-04	1.0E-03	-2.9E-02
Resource use, energy carriers	MJ	1.1E+01	3.4E+00	2.2E-01	1.4E+00	5.7E+00	9.1E-02	1.6E-01	-2.2E-01
Resource use, mineral and metals	kg Sb eq	3.6E-06	1.5E-06	7.0E-09	1.7E-07	1.9E-06	2.6E-09	8.1E-09	-3.7E-08

* The use phase only consists of transport from retail to consumer. The emissions from transport are reported in the distribution life cycle stage. Therefore, the use stage is excluded in this table.

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
- Freshwater and terrestrial acidification
- Water scarcity
- Respiratory inorganics
- Terrestrial eutrophication
- Photochemical ozone formation

The **most relevant life cycle stages** are cultivation, distribution and end of life.

The **most relevant processes** are:
- Agricultural machinery, unspecified
- Ammonium nitrate, as N
- Banana production
- Biowaste / treatment of biowaste, industrial composting
- Corrugated board box
- Electricity, low voltage {EC}
- Irrigation {EC} | processing
- Polyethylene, high density, granulate
- Sulfate pulp production
- Transport, freight transport by sea using a transoceanic ship with cooling
- Transport, passenger car
- Transport, freight, lorry with reefer, cooling

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) resulting from the insights provided by the banana RP study (Note: DQRs range from very good (1) to very poor (5) quality)*

Life cycle stage	Data collection needs	Data quality requirement (DQR)
Cultivation	Amounts of inputs and elementary flows	DQR≤1.6
Post-harvest handling	Specific data required	DQR≤3.0
Packaging	Amounts of main materials	DQR≤3.0
Distribution	Distance and mode	DQR≤1.6
Retail	Generic data allowed	DQR≤3.0
Consumption	Generic data allowed	DQR≤3.0
End of life	Percentages and types of waste treatment, generic data allowed	DQR≤1.6

Disclaimer

The screening 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.

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