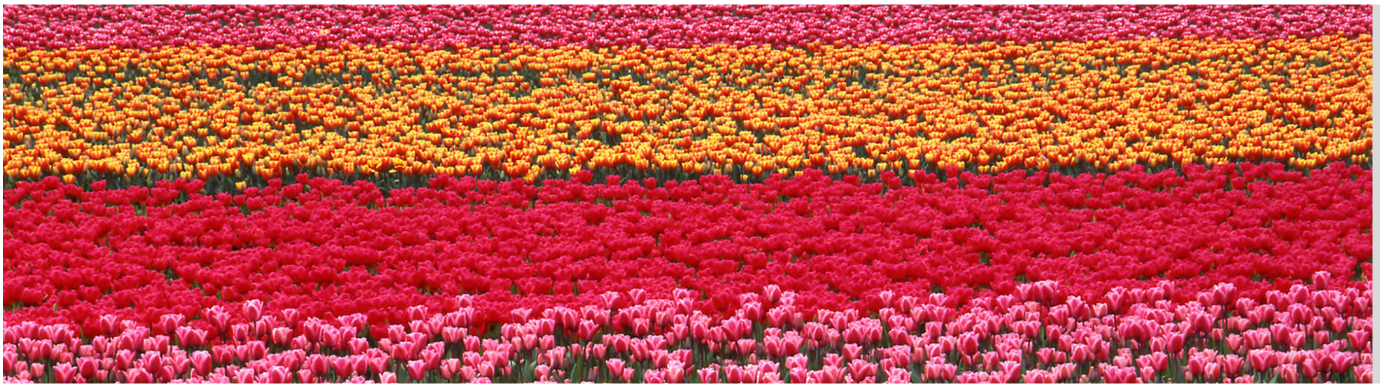

Environmental footprint of tulip bulbs: Summary of the representative product study

Pietro Goglio

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 tulip bulbs grown in the Netherlands in open field conditions, which was completed in 2019. The results can be used for tulip bulbs grown in similar soil climate conditions as in the present study (clay loam and sandy soils in the Netherlands). A complete horticultural footprint study will include processing, use and end of life.

Goal & scope

The representative product under study is tulip bulbs grown in open field conditions. 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 tulip bulbs, the functional unit (FU) being one tulip bulb at commercial grade. In contrast to the other five studies of representative products as mentioned in the Introduction, this study is limited to two phases (cultivation and post-harvest handling), as following the storage of tulip bulbs the downstream processes are targeted to three separate products (bulbs, vase plants and cut flowers) for which different product category rules apply. Further, this RP study aims to be representative of other bulb production which is either not used as cut flowers (e.g. *crocus sp*) or used directly for human consumption (e.g. onions).

The system includes all the direct input involved with tulip bulb production: tillage, fertiliser, pesticides, storage, nursery and irrigation. It distinguishes between sandy soil corresponding to the area between Amsterdam and Den Haag, and the clay soils which represent the large majority of soils corresponding to the north region and the polder areas around the Ijsselmeer.

Each year, 10 t ha^{-1} of tulip bulbs are planted, while the average harvest is 28 t ha^{-1} of tulip bulbs of which only 15 t ha^{-1} are commercial grade. For the rest, 10 t ha^{-1} are replanted the following season and the other 3 t ha^{-1} are disposed of as compost.

After harvest, the tulips are dried and stored for 2–3 months in 100 kg wooden boxes. The drying process is carried out through electrical fans and heating when the autumn temperature drops.

The heating is provided by a gas boiler.

Data collection and modelling

The following key methodological choices and assumptions were made:

- Each ha of land produces 500,000 per year of acceptable commercial quality product.
- Ten pesticide spraying operations were carried out every year.
- A total of 177 kg of N fertiliser was spread every year together with 9 kg of P per ha^{-1}.
- The location of the agricultural input retailer was assumed to be 10 km away from the location of the farms.
- The nursery phase was based on tulip breeder interview data. In particular, the following selection rate was assumed: 10% over three years for the first three years, 10% over the fourth year, while in the following 15 years the selection rate would be 69% every year.
- The nursery cycle lasts 19 years of which 15 are in open field conditions.
- Tulip planted in clay soil conditions are irrigated 10 times over two months. In each irrigation event, 30 mm is distributed. Tulips are also grown in a plastic net which is put into the soil during bulb transplant and collected at harvest. The net is then washed and sold as plastic. No impact was assessed after this process, as this will be included in different systems as raw material.
- Field nitrous oxide, 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 several researches highlighting its importance (Brandão et al., 2013; Garrigues et al., 2012; Goglio et al., 2015, 2017).

Foreground data was collected from farmer associations, interviews with farmers, farm equipment dealers and the literature as mentioned above. For storage, retail and the use stages, datasets were created using default data for these processes using the PEFCR guidance documentation (EC, 2018). The end of life was modelled using details in the Annex C from the same document.

For the background data and the greenhouse, ecoinvent version 3.4 cut-off (Wernet et al., 2016) and Agri-footprint 4.0 (economic) have been used (Agri-footprint, 2018a, 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;
- Respiratory inorganics;
- Terrestrial eutrophication;
- Freshwater ecotoxicity (not included in the weighted results, but considered as relevant due to the perceived importance of the environmental impact of pesticides).

Figure 1 and Figure 2 show the contribution of the tulip bulb life cycle stages to the relevant impact categories. From this we observe that the most relevant life cycle stage of the tulip is other processes in cultivation (in the clay soil, it includes crop protection) and crop protection is followed by straw spreading and nursery.

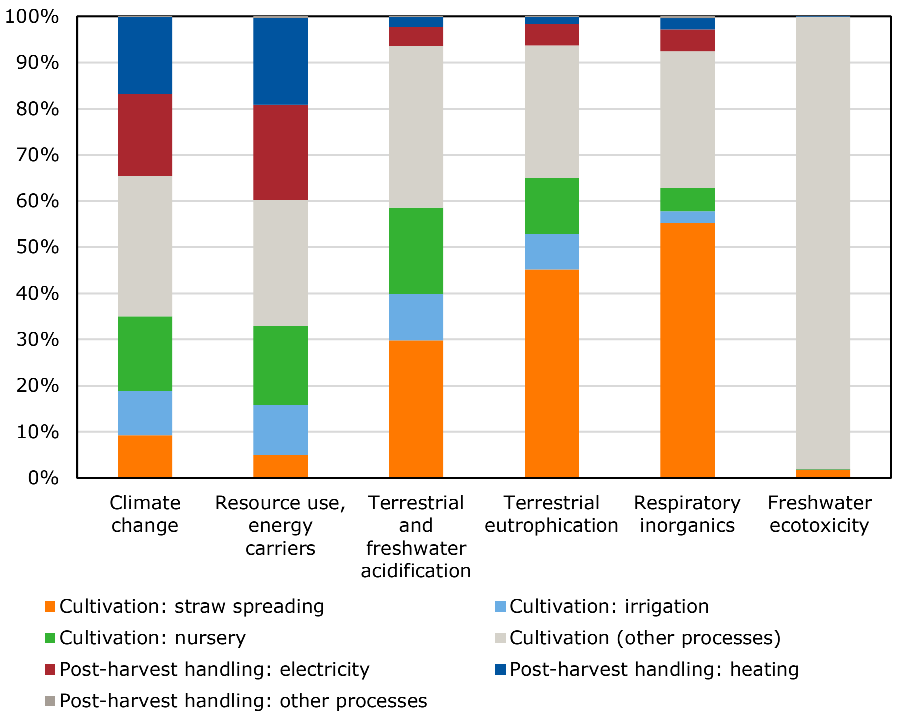

Figure 1 *Contribution of the life cycle stages of tulip cultivation in clay soils to the relevant impact categories*

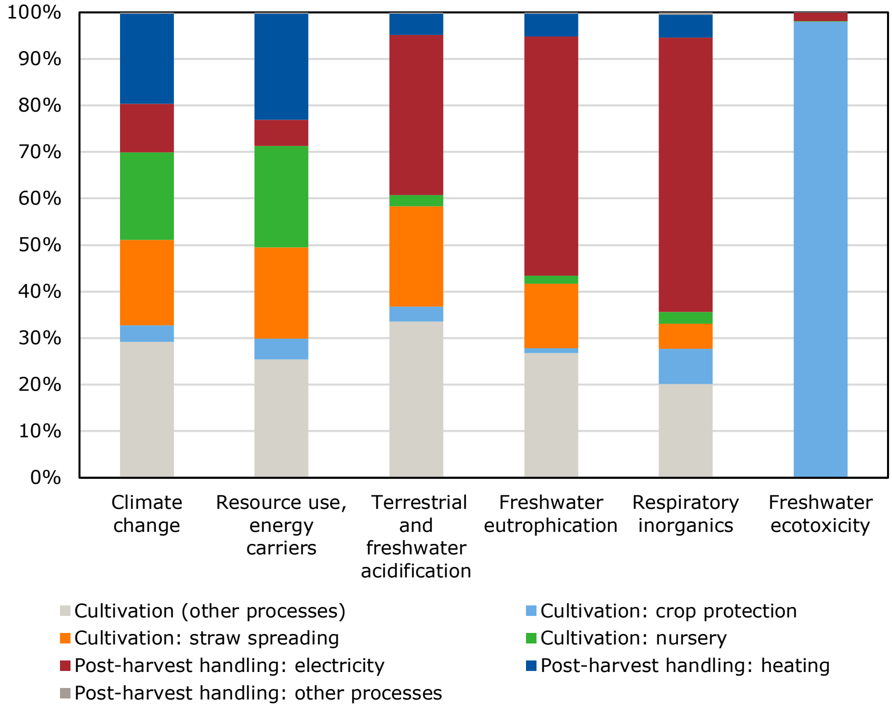

Figure 2 *Contribution of the life cycle stages of tulip cultivation in sandy soils to the relevant impact categories*

The most relevant processes and most relevant elementary flows are shown in Table 1 and Table 2, respectively.

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

Process	Stage	Climate change		Resource use, energy		Aquatic and terrestrial acidification		TE		Respiratory inorganics		FE	
		clay (%)	sand (%)	clay (%)	sand (%)	clay (%)	sand (%)	clay (%)	sand (%)	clay (%)	sand (%)	clay (%)	sand (%)
Electricity	Post-harvest handling: electricity	18	19	21	23	4	5	4	5.0	5	5		
Heat	Post-harvest handling: heating	17	19	19	22		2						
	Cultivation: nursery	13	15	13	15								
Irrigation	Cultivation: irrigation	8				8		7					
Seed Bulbs cultivation	Cultivation: other processes	12	13			14	16	11	12	9	9		
Wheat straw	Cultivation: straw spreading	4	4			24	27	38	42	46	49		
Polyethylene production	Cultivation: other processes	4	4	10	10					4	4		
Diesel	Cultivation: straw spreading. Cultivation: irrigation. Cultivation: other processes. Post-harvest handling: other processes/cultivation: nursery	3	2	25	17	4	3			6	4		
	Cultivation: other processes	3	4			4	4	3	3				
	Cultivation: crop protection. Cultivation: other processes												
Tulip nursery controlled conditions IV year	Cultivation: nursery					8	9	4	5				
Biowaste treatment	Cultivation: other processes. Cultivation: nursery					6	4	9	6	8	5		
Tulip nursery plot conditions clay	Cultivation: Nursery					6		3					
Tulip nursery controlled conditions I-III year	Cultivation: nursery					3	4						
Tulip nursery plot conditions sand	Cultivation: nursery						6		4				
Ammonium nitrate production	Cultivation: straw spreading. Cultivation: nursery. Cultivation: crop protection								2		3		
Wheat grain production	Cultivation: straw spreading						2	3	3	3	4		
Pesticides production and transport	Cultivation: other processes											97	97
Remaining processes		18	20	12	13	19	18	18	18	19	17	3	3

Table 2 *Most relevant elementary flows contributing in total at least 80% to the impact of one or more relevant impact categories*

Elementary flow	Compart-ment	Climate change		Resource use, energy		Aquatic and terrestrial acidification		Terrestrial eutrophication		Respiratory inorganics		Freshwater ecotoxicity	
		clay (%)	sand (%)	clay (%)	sand (%)	clay (%)	sand (%)	clay (%)	sand (%)	clay (%)	sand (%)	clay (%)	sand (%)
Carbon dioxide, fossil	Air	76	74										
Dinitrogen oxide	Air	16	18										
Oil, crude	Raw			34	27								
Gas, natural/m^3	Raw			32	36								
Peat	Raw			12	14								
Coal, hard	Raw			11	12								
Ammonia	Air					61	67	71	75	64	66		
Nitrogen oxides	Air					22	15	18	13				
Particulates, < 2.5 um	Air									23	22		
Folpet	Soil											65	65
Tralomethrin	Air											4	4
Tralomethrin	Water											15	15
Remaining substances		8	8	11	11	17	18	11	12	13	12	16	16

Overall appreciation of the uncertainties of the results

The following factors have the most influence on the uncertainty:

- Practices across tulip growers are subject to climate, soil and local conditions variability. Regarding crop protection, they also depend on the perceived risk by farmers.
- Several fate emission factors have been considered following the procedure proposed by Goglio et al. (2018) in agreement with previous research (Audsley et al., 1997), however this do not take into account soil climate interactions.
- The elementary flow data of 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 significant effect on the terrestrial and freshwater acidification, and the terrestrial eutrophication impact category.

The sensitive foreground data were estimated based on several sources, which may not always be representative for common practice and therefore 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 3.

Table 3 *Data Quality Requirements (DQR) for the different life cycle stages for tulip bulbs*

Life cycle stage	Current DQR	Data quality requirement (DQR score)
Cultivation	Amounts of inputs and elementary flows	<1.5; Very good to excellent quality; primary site specific
Post-harvest handling	No post-harvest handling	Not applicable
Packaging	Generic data allowed	Not applicable
Distribution	Distance and transport mode	Not applicable
Storage	Generic data allowed	<1.5 Very Good to excellent quality; primary/site specific
Retail	Generic data allowed	Not applicable
Use	Generic data allowed	Not applicable
End of Life	Percentages and types of waste treatment, generic data allowed	Not applicable

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.

Acknowledgement

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More information
Dr Pietro Goglio
T +31 (0)6 28 52 29 01
E pietro.goglio@wur.nl
www.wur.eu/economic-research

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