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Streamlining life cycle inventory data generation in agriculture using traceability data and information and communication technologies – part II: application to viticulture

Véronique Bellon-Maurel [a,*], Gregory M. Peters [b,c,1], Sonia Clermidy [a], Gustavo Frizarin [d], Carole Sinfort [d,2], Hernan Ojeda [e,3], Philippe Roux [a], Michael D. Short [b,f,4]

[a] Irstea-Montpellier Supagro – UMR ITAP, ELSA Group, BP5095, 34033 Montpellier Cedex 1, France
[b] UNSW Water Research Centre, School of Civil and Environmental Engineering, University of New South Wales, Sydney, New South Wales 2052, Australia
[c] Chemical and Biochemical Engineering, Chalmers University of Technology, 41296 Gothenburg, Sweden
[d] Montpellier Supagro – Irstea – UMR ITAP, ELSA Group, 2 place Viala, 34000 Montpellier, France
[e] INRA – UE999 Pech Rouge, F-11430 GRUISSAN, France
[f] Centre for Water Management and Reuse, School of Natural and Built Environments, University of South Australia, Adelaide, South Australia 5095, Australia

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ABSTRACT

Agricultural systems are increasingly subjected to environmental life cycle assessment (LCA) but generating life cycle inventory (LCI) data in agriculture remains a challenge. In Part I, it was suggested that traceability data are a good basis for generating precise LCI with reduced effort, especially when collected by efficient information and communication technologies (ICTs). The aim of this paper is to demonstrate this for wine grape production and generate a list of data to be collected for streamlined LCI generation. The study is carried out in the South of France, on a viticultural farm implementing electronic traceability of each cultivation operation, i.e. tillage, fertilisation, crop protection, weeding, canopy management and harvesting (no irrigation is needed at this vineyard). For each operation, specific emission models which satisfy the trade-off between accuracy and need for data have been identified. Traceability data must be supplemented with data related to the plot, equipment and inputs to feed the models. The sensitivity of the LCA outputs to plot soil type and year of cultivation was studied. Consistent with previous agricultural studies, the results show that operations such as pesticide spraying and fertilising have large environmental impacts in this Mediterranean vineyard. Notable variations occur in life cycle impact assessment indicators, principally due to variations in crop yield; however, the influence of secondary factors such as soil type and agricultural practices is also evident and this contribution allows us to better characterise the variability of grape production and to show that streamlined LCI can be created using traceability data. Ultimately, this paper delivers two results. It provides simple models, and relevant data and methodology to enable viticultural LCAs to be undertaken. Additionally, it demonstrates that accurate LCIs can be built based on data already collected for traceability when supplemented with other easily collectable data (weather and farm structural data). Overall, this work paves the way for streamlined LCI in agriculture.

1. Introduction

In a first paper (Bellon-Maurel et al., 2014), several approaches were presented for streamlining life cycle inventory (LCI) data generation in agriculture and therein a new approach, called the "traceability" approach was advocated, in which "traceability data" and, where possible, data collected by information and communication technologies (ICTs), are used to generate LCI data. Traceability is defined as "all compulsory or voluntary on-farm records".

* Corresponding author. Tel.: + 33 4 67 04 63 19; fax: + 33 4 67 04 63 06.
E-mail addresses: veronique.bellon@irstea.fr (V. Bellon-Maurel), petersg@chalmers.se (G.M. Peters), sinfort@supagro.inra.fr (C. Sinfort), ojeda@supagro.inra.fr (H. Ojeda), philippe.roux@irstea.fr (P. Roux), michael.short@unisa.edu.au (M.D. Short).
[1] Tel.: +46 31 772 30 03; fax: +46 31 772 2995.
[2] Tel.: +33 4 99 61 23 24; fax: +33 4 67 04 63 06.
[3] Tel.: +33 04 68 49 44 08; fax: +33 04 68 49 44 02.
[4] Tel.: +61 8 8302 3496.

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The aim of this second paper is to demonstrate that traceability data are a good basis for generating LCIs in viticulture, provided that appropriate emission models are used and that certain additional data are available. To achieve this, a life cycle assessment (LCA) is performed on a case study vineyard in southern France using data from cultivation registers. Viticulture was chosen because emissions can be very site-specific and grapevines are grown worldwide in diverse climates using a large range of techniques. Moreover, few LCAs of viticultural systems exist in the literature (Aranda et al., 2005; Pizzigallo et al., 2008; Gazulla et al., 2010; Vázquez-Rowe et al., 2012).

In France, the requirements for traceability in viticulture include 19 documents, with information on the farm (crop rotation, vineyard setting, etc.) and on operations (fertilisation, crop protection, irrigation, harvesting) (Abt et al., 2007). Traceability data can, therefore, cover a broad range of viticultural operations; however, using such data for LCI generation is not straightforward, as it is expressed in units related to the agricultural activities (e.g., fertiliser type and quantity) rather than units of emitted substances. Emissions may be computed by using emission factors attached to activities based on international LCA databases such as Ecoinvent. A more accurate alternative is to use local emission models, but this requires additional data (Poppe and Meeusen, 2000). In agriculture, such data can be classified as:

- "Structural data" about production methods (e.g., plot size, grape variety, slope, soil type and machinery);
- "Activity data" related to the agricultural operations;
- "Weather data" which are easily obtained from meteorological stations.

The objective of this paper is to demonstrate that the use of traceability data for LCI generation provides accurate results with minimal effort and is a sound approach for streamlining LCA in agriculture. After introducing the case study system, the paper describes the LCI generation phase wherein emission sources in the grape production system are identified and linked to simple emission models, followed by a description of which data must be recorded to compute these emissions. An LCA is then performed with regard to grape production and a sensitivity analysis undertaken to test the robustness of results relative to production year and soil type. The outputs of the paper are: a specification sheet for building an LCA-ready traceability database from data already recorded in viticultural traceability systems; and a full LCA of wine grape production validating the traceability-derived LCI approach.

2. Case study description and modelling approach

2.1. LCA methodology

Established LCA methodology, more thoroughly described in Part I is followed: first, the goal and scope of the study are defined; second, the LCI is constructed; third, the impacts and damages are computed from the inventory via well-known life cycle impact assessment (LCIA) methods; finally, data are interpreted and a sensitivity analysis performed (ISO, 2006). The LCA software SimaPro 7.3.3 (PRé Consultants, NL) was used and the LCIA undertaken using ReCiPe Midpoint (H) 1.07 'hierarchist' consensus model. The H (hierarchical) method is considered the default model and represents a compromise between the 'individualist' approach (which uses only proven cause–effect relations in a short-term techno-centric perspective) and the 'egalitarian' method (which is based on the precautionary principle and adopts a longer-term perspective). Ecoinvent v2.2 (Swiss Centre for Life Cycle Inventories at www.ecoinvent.ch) was used to find LCI data for background processes, but for the foreground processes specific to viticulture, emissions/consumptions were computed based on models of each operation.

2.2. Goal and scope

The case study system is one of wine grape production from an experimental 100-plot vineyard owned by INRA in the south of France, where a Mediterranean climate prevails (Pech-Rouge, Gruissan). The cradle-to-farm gate LCA case study describes the production of 1 kg of grapes (functional unit) of one variety (Syrah) in five case study configurations representing variable conditions: three plots (P 22, P 80 and P103) are selected in three different zones to demonstrate the influence of different soil properties. Additionally, one plot (P80) is studied in different years (2004, 2006 and 2008) to examine temporal variability. The geographic boundaries of the study are those of the farm; the transfers from the farm buildings to the plots are not taken into account except for the grape harvesting, as transfers can be numerous. The construction of farm machinery is taken into account, based on the

Table 1
Example of a traceability log table from the Agreo software (here plot P80, year 2006) (Source: INRA).

Name:	# 80	Species:	Vineyard		
Zone:	XXX	Variety:	Syrah		
Area:	0.69 Ha				
Harvest:	2193 kg				
Fertilising	Commercial name	Quantity	N	P	K
28/09/2006 – Fertilisation	Orga 3 (3-2-3)	907 kg	27	18	27
Harvest	Input name		Quantity		
30/08/2006 –Harvest			2193 kg		
Pesticide spraying	Commercial name	Quantity	Target		
11/05/2006 – Miscellaneous	Acarifas	0.5 L/Ha	Clysia		
	Sabithane	0.3 L/Ha	Powdery Mildew		
	Epylog	3 kg/Ha	Mildew		
	Goemar vitiflo E	3 L/Ha			
22/05/2006 – Miscellaneous	vitiflo E	3 L/Ha			
	Corail	0.4 L/Ha			
	pantheos (4522C8)	2 kg/Ha			
06/06/2006 – Miscellaneous	Quadris	2 L/Ha			
	Vivifruit	1 L/Ha			
15/06/2006 – Fungicide	Sulphur (4/336)	30 kg/Ha			
23/06/2006 – Miscellaneous	Cascade	0.4 L/Ha	Clysia		
	Karaté K	0.125 L/Ha	Leafhopper		
	Microthiol	10 L/Ha	Powdery mild.		
08/07/2006 - Fungicide	Vifolcuivre2	3/Ha	Mildew		
	Heliosoufre	7.5 L/Ha			
27/07/2006 – Miscellaneous	Champ Flo	4.3 L/Ha	Mildew		
	Steward	0.125 U/Ha	Clysia		
Tillage					
03/03/2006 – Harrowing					
24/04/2006 – On-the-row weeding					
16/05/2006 – Harrowing					
17/05/2006 – Interstock tillage					
02/10/2006 – Harrowing					
Canopy management			Output Quantity		
13/06/2006 – Trimming					
03/08/2006 – Trimming					
01/12/2006 – Pruning			Unknown		
05/12/2006 – Pruning residues shredding					