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ABSTRACT

All stakeholders, from consumers to regulators are beginning to demand that French viticulturists reduce their environmental impact, but not at the expense of the quality of the wine. This position paper presents the approach to evaluate the compatibility of grape quality and environmental objectives in Central Loire Valley PDO (Protected Designation of Origin) vineyards. The environmental quality of vineyard management strategies will be assessed using the LCA method. The adaptations and choices to be made for LCA implementation are discussed. The data handling necessary to build the typology of production strategies and confront both the product and environmental quality of vineyard management are exposed.

Keywords : viticulture, Life Cycle Assessment, grape characteristics, multi criteria rating, functional unit

1. Introduction

Social and economic pressure on the wine sector to adopt sustainability is growing. French government's policy on ecological and sustainable development includes the target of a 50% reduction in the use of pesticides between 2008 and 2018. A new requirement for environmental information on mass consumption products could be imposed after 2012 ("Act Grenelle 2"). This is relevant to the wine sector.

French consumers embrace the tradition and natural aspects of wine and their affinity to it might be eroded by their evolving knowledge of production practices (Brugière, 2009). They are concerned of the risk of agrochemical spraying on crops affecting their diet (Credoc, 2009). The image of wine could be jeopardised by the use in viticulture of 20% of pesticides (in mass) on 3.7% of French UAA (Aubertot *et al*., 2005). Protected Designation of Origin (PDO) wines embody the localized and traditional technical know-how, but the PDO is a guarantee of origin, but not environmental quality.

The French PDO wine producers are thus faced with this new societal and institutional demand. Similarly, they must take into account the environmental requirements of key international markets. It is then necessary to assist the wine industry in addressing this issue through the evolution of its practices towards being more environmentally friendly. The grape growers of the Loire Valley are seeking support for such development in an environmental practice without damaging the quality of their wines.

This paper introduces the approach implemented in order to provide, to wine sector agents, inputs useful for choosing vineyard management strategies that meet the objectives of product quality and environmental quality. Environmental quality will be assessed by Life cycle assessment (LCA). This project is developed in the frame of the scientific programme

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of UMT Vinitera[1] and targets Loire Valley PDO vineyards. The research is partially funded by Loire Valley Wines Organisation. The originality of this research is situated in product multi-criteria rating of quality and environment, which corresponds to a new research field emerging internationally, and in the adaptation of LCA to the wine grape production.

2. Objectives

This project aims to i) measure the levels of compatibility between indicators of grape quality (Qg) and of environmental quality (Qe) of the vineyard management strategies[2] (VMS) in these attributes ranging from antagonistic to synergistic relationships, ii) to identify, within the VMS, the techniques responsible for these situations, in order to assist wine industry stakeholders in the choice of VMS.

The research strategy intends to i) identify the diversity of existing vineyard management practices, ii) establish a typology of VMS, iii) chose existing vineyard plots representing this diversity as an experimental network, iv) characterize the soil and climate of these plots as co-variables, v) observe the VMS on the plots for three years on the attributes of Qe and Qg, vi) cross Qe and Qp indicators of VMS in a matrix structured in degrees of compatibility, vii) identify the parts of the process playing the main role on the VMS position in the matrix, and viii) adapt the matrix into a tool for wine sector agents.

3. Method

This research focuses on grape production, which represents a significant part of the environmental impacts of wine (Gazulla *et al.*, 2010) and is an important aspect of the quality of the product. One of the two major cultivars of the central Loire Valley: Chenin B. (white) and Cabernet Franc (red) will be utilised. Measurements are planned for 3 consecutive vintages (2010-2012) and will be performed at the plot level (a single unit in the vineyard with homogeneous characteristics). The project will be conducted in conjunction with key stakeholders so it has strong application in the wine sector.

This research is broken down into five stages:

Stage 1: Establishment of the experimental and observational network representing the diversity of VMS of central Loire Valley PDO vineyards *Year 1*.

The diversity of VMS existing in the region is identified by:

- A survey of 67 grape growers with diverse socio-economic profiles, different production systems, from different PDO, in order to describe their VMS on 158 plots.
- A typology of VMS from this survey and existing databases on 40 variables using the data mining platform CORON (Ducatel *et al*., 2010), and Factorial Multiple Correspondence Analysis (FMCA).

The sample of plots used for the study will be selected by VMS types in order to contrast potential Qe and Qg. Two networks will be designed: one comparing VMS in the same environment (soil, climate) and the other observing VMS in various environments.

Stage 2: Evaluation of Qg and Qe on the selected plots VMS *Years2,3,4*

The evaluation of Qg requires the following:

- The choice of grape quality criteria (biochemical, sensory, physical, microbiological, xenobiotics) through a survey with expert winemakers.

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[2] Logic succession of techniques applied on the vineyard by the producer

- The measure of grape quality on the chosen criteria at harvest.

The evaluation of Qe requires the following:

- Adaptation of the LCA method for wine grape production (functional unit, impacts, completion of Eco-invent data base) following the iterative process of LCA.
- Calculation of environmental impacts using LCA (Simapro software, Ecoinvent database).

An inventory of flux data will be made with grape growers once or twice a year depending on their practices traceability.

Stage 3: Evaluation of the compatibility of Qe and Qg for each VMS *years 2,3,4*

The environment (soil and vintage climate) will be characterised as co-variables through existing detailed cartography and annual weather data.

Qe and Qg datasets will be crossed using Multiple Factorial Analysis (MFA) and including environmental co-variables.

VMS will be positioned in a matrix crossing Qg and Qe following the design of:

- A typology of Qg and Qe through a combination of criteria
- A matrix of compatibilities between Qg and Qe using this typology

Stage 4: identification, within VMS, of vineyard management techniques responsible of VMS position in QgXQe matrix *year 4*

The key techniques influencing grape quality will be identified through literature review. The techniques causing the main environmental impacts will be identified both by LCA results on the experimental network and literature.

Stage 5: Development of a tool to assist the wine sector agents in their VMS choices *Year 4*.

The tool will be developed from the matrix.

4. Methodological issues

This approach identifies five main methodological issues. LCA adaptation to the grape production process and the treatment of complex data are the focus of this paper. The relevance of considering 3 vintages for this study is developed in another article (Renaud *et al*., 2010 (b)). The choice of grape quality indicators to be considered for Qg evaluation and construction of a tool to aid decision making will be developed in a subsequent paper.

LCA has been chosen for the evaluation of the environmental quality of the VMS because it is the most complete tool in the field of global and multi-criteria assessment of environmental impacts. It has recently been chosen, in a simplified form, to assess and display the environmental impact of consumer products in France, which directly concerns the wine industry. However, this method only deals with potential impacts and appropriate models for impacts on biodiversity and soil quality are still under construction. Currently, estimation of the uncertainty of results remains difficult in agricultural LCA (Payraudeau *et al.*, 2005).

The method is currently applied and adapted to agricultural systems and of particular interest to this research, perennial fruit production as well (Mouron *et al*., 2006). Research utilising LCA in viticulture and oenology has been published (Aranda *et al.*, 2005; Petti *et al.*, 2006; Pizzigallo *et al.*, 2006; Gazulla *et al.*, 2010), but have not addressed the method in detail for application in vineyard management.

Implementation of the method will therefore be needed on aspects specific to vineyard management.

Limits of the system: The assessed product being grape, winemaking process can be ignored provided changes in VMS do not affect the winemaking process impacts or only

marginally. In the case of a significant variation of the winemaking phase impacts due to VMS modification, this variation will be identified and quantified to be added to the VMS impacts.

The period considered is the production year from harvest to harvest. Even if in the case of such a perennial plant, back effects of some practices from the past years can affect yield and quality, they will be considered as marginal. We will consider non productive phases of the vineyard (plantation, pulling) as identical for all VMS. They will be simplified and amortized on 25years, usual amortizing duration for vineyard planting in accountancy. However, if important differences between the VMS appear on these phases it will be explored in more details. If the life duration of the vineyard appears to be dependant on VMS the amortizing period will change according to the VMS.

Impacts categories: Viticulture classical practices can cause different impacts on the environment (Renaud *et al*.(a), 2010): water and air pollution from pesticides, soils pollution mainly due to copper spraying on vines for decades, soils erosion because vineyards are often planted on slopes, greenhouse gases production, use of non renewable resources of which fuels take an important part, and biodiversity depletion, mainly due to pesticides use and monoculture.

These key impacts will be considered for the choice of LCA impacts categories.

Choice of Functional Unit (FU): Multifunctionality and specificities of viticulture lead to consider different FU:

- In most cases, yield and quality of grapes, especially sugar and polyphenols content, are negatively correlated. This is even more observed in cool climate vineyards as Loire Valley ones, (Huglin and Schneider, 1998). A FU considering only the mass of production, as usual in agriculture (Hayashi et al. 2005), would disadvantage most qualitative grape production.
- The primary function of grape production is to achieve the best trade-off between a targeted multi-criteria quality level and the highest possible yield, within the limits determined by specifications in PDO areas. It is, therefore, important that FU includes quality parameters associated with yield as Charles *et al*. (1998) propose on wheat.
- Quality objectives are essential in viticulture, and their nature depends on the expected product (white wine, light or full bodied red wine...), The quality parameters included in FU and their levels need to be different according to the type of wine produced.
- Global grape quality could be represented by the monetary value of the grapes. However, the grapes processed on farm, which is a common situation in Loire Valley, are not object of financial transaction. This value could be deducted from the wine value, but the wine value is often not directly correlated to its organoleptic quality, but partly depending on fame of the PDO or of the company. The “financial function” of the grape (Nemecek *et al*., 2007) won’t be easy to evaluate.
- Vine, as a perennial crop, occupies land for several decades and vineyard has an important function of maintaining space and landscape value (Joliet, 2003). Nemecek *et al*. (2007) measure this “land management function” by hectares time years. Since working at the vintage temporal scale, it seems here inappropriate to include time in the FU.

To estimate the influence of the choice of FU on calculated impacts, LCA calculations will be performed with four different FU: 1kg wine grape, 1kg grape presenting a defined level of quality parameters to be chosen in interaction with wine sector agents and 1ha vineyard. A monetary FU should be defined and tested.

Complex information treatment will be used at three main steps of the project: establishment of the VMS typology and of Qe and Qg typologies and crossing of Qg and Qe of the VMS.

The data from the survey about existing VMS in the Middle Loire Valley vineyard will be completed by recent existing databases describing VMS in the same region and same

cultivars, to build VMS typology. The VMS are described in these databases by a list of 100 variables about vineyard management practices. They consist in practices list and their attributes. They include also data on wine quality obtained from the plot, and data on plot attributes (slope, precocity …). Two methods of typology construction will be compared: Factorial Multiple Correspondence Analysis and use of a data mining platform, CORON. Coron platform extracts patterns (frequent, closed, etc..) and then generate association rules (Ducatel *et al*., 2010).

To identify situations of compatibility or antagonisms between the qualitative and environmental objectives, it is planned to cross Qe and Qg datasets for observed VMS. Both Qe and Qg will be multicriterial. Two methods are considered. The first is a direct statistical treatment of the data sets through Multiple Factorial Analysis (MFA) (Escofier and Pagès, 1998). MFA is a method of analysis of multiple tables in which individuals are described by several groups of quantitative or qualitative variables. The second is the construction of a matrix where the VMS will be situated according to their Qe and Qg types. This implicates the definition of, in one hand, a typology of grape qualities based on combinations of different quality criteria levels, and in the other hand, of a typology of environmental qualities also based on combinations of different levels of the impacts assessed by LCA. The plot environment (soil, climate) needs to be taken into account as a co-variable, for it has a strong influence on yield and grape quality.

5. Conclusions

The expected results are i) the identification of VMS diversity, ii) a built typology of Loire Valley VMS for the studied cultivars, iii) an operational method to characterize VMS by the relationship between Qe and Qg, iv) the positioning of each VMS type within the QeXQg matrix, structured in increasing degrees of compatibility, v) a list of the vineyard management techniques responsible for this position in the matrix VMS QeXQg, vi) an advisory tool developed with the actors from this matrix, vii) adapted LCA method for grape production processes in the Loire Valley, viii) results of methodological development on LCA which should benefit viticultural scientists and technicians wanting to use LCA for wine grape production. This work should also contribute to improve multi criteria methods for production processes evaluation.

These results should provide the wine industry the opportunity to increase its awareness of environmental issues and to further increase the environmental quality of grape production processes. The findings could contribute to changes in viticulture towards more environmentally friendly practices. This research could propose new tools for actors in charge of advising the wine sector and enable them to better integrate environmental objectives into the specifications of labelled productions, including PDO, in line with consumers and societal expectations.

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