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Sustainability in mountain viticulture . The case of the Valle Peligna.

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Abstract

The production of Montepulciano wine in Italy represents an important factor in the agricultural sector, being the second tree crop for area involved and the first for turnover produced. In this context, the mountain viticulture stands out from the others for various reasons, such as the lack of mechanisation, the low yield per hectare and its strong links with the surrounding territory, of which it has also become a landscape-heritage protection tool. The Peligna Valley is an inland zone of the Abruzzo region that houses a number of typical agricultural products, out of which winemaking stands out. Within the framework of a project financed by the Abruzzo Region with funding from the 2007-2013 RDP, the methodology of Carbon Footprint (OIV 2013. ISO 2013) was applied to the production of Montepulciano wine and the OIV (International Organisation of Vine and Wine) guidelines on sustainable and durable viticulture (CST 1-2004 and 1-2008 CST) were verified and applied. Therefore, the agricultural and oenological phases excluding the packaging, transport and consumption phases of two consecutive years were analysed. In this period, measures to reduce environmental impacts have been implemented. A deep analysis of the data revealed that the most impactful phase is farming, instead of the winemaking phase that represents an item much smaller in terms of GHG emissions. It was also seen that, thanks to the adoption of actions to reduce emissions, an improvement of the environmental performance was identified ranging from 7% and 15% of the total.

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1. Introduction

Over the last 20 years numerous contributions on issues concerning the impact of climate change on agriculture have been published (Olesen and Bindi 2002, Fuhrer 2003, Grünberg et al 2007). According to the IPCC (Intergovernmental Panel on Climate Change, 2006), global warming could affect worryingly the agricultural production (Easterling et al. 2007; Eggleston et al. 2006; Duchene and Schneider 2005; Wolfe et al. 2005). The concern resides in the significant impact that climate changes may have on the growth of crops, (strictly dependent on the weather).

There are, in this sense, models that can predict the yields of crops with regard to the effects of climate change, and in that sense the temperature plays an important role in the regulation of plant phenology.

The effects of the growing temperatures are already evident on the phenological cycles of crops (Mariani et al. 2009) in Europe and in many other parts of the world (Chuine et al. 2004, Meier et al., 2007, Schleip et al. 2008). Over the past 20 years, climate change has affected the weakest and most fragile ecosystems, such as alpine and subalpine, which are known to be particularly sensitive to temperature changes. Precisely for this reason, mountainous agricultural ecosystems have been included in the list of the most vulnerable to the impacts of climate change by the Food and Agriculture Organization (FAO). Viticulture –strongly diversified- is placed in this scenario, which has actually become a “Global" industry, from the markets point of view. This represents a considerable demand for the world's resources. According to what has been said so far, it is clear that there is a strong link between climate and vine and this also implies that the effects of climate change on viticulture could be more significant in mountainous ecosystems. Furthermore, changes in temperature may influence the length of the growing season and the quality of the grape harvested, thus determining the profitability of viticulture. As it is known, the quality of the grapes depends on the meteorological situation during the growing season, and particularly during the immediately preceding period (Jones et al., 2005, White et al., 2006, Moriondo and Bindi 2007). The aim of this work is to present the results of a project that began in 2013 and applied the methodology of Carbon Footprint and the OIV guidelines for durable and sustainable winemaking, to the case studies in Abruzzo. The situation of the regional wine will presented, followed by the methodology of LCA and carbon footprint and then the results of the study will be described and some conclusions about the experience obtained will be drawn.

1.1. Wine Industry in Abruzzo

In Abruzzo, growing grapes for wine cover an area of 36,000 hectares with an annual production of 3.8 million hectolitres (ISTAT 2010). The production of wine with denomination of origin reaches one million hectolitres, more than 800 thousand of which refer to Montepulciano d'Abruzzo, 192,000 to Trebbiano d'Abruzzo, 4,000 to Controguerra DOC and to DOCG Montepulciano d'Abruzzo Colline Teramane .

In the different production areas, wine making is characterized by a high degree of integration between the production and the processing phase up to take on a strategic role for the local socio-economic system.

Three-quarters of the total production of wine in Abruzzo come from 40 cooperative wineries (32 of which are operating in the province of Chieti), which, together with private ones compose a framework of 160 processors, 120 of which bottle with their own label. In the context of viticulture, the mountainous one, whilst being at modest levels in terms of surface and production at a regional scale, it assumes considerable importance in the province of L'Aquila for which is an interesting source of income and employment and a secular tradition to carry on, within which land conservation and environmental protection are performed as well.

1.2. The Valle Peligna Area

The Valle Peligna area is a plateau of Abruzzo, located at the centre of the region, in the province of L’Aquila, which has an average altitude of about 500-600 m above sea level and an area of about 100 km2. It enjoys a particularly hot summer weather (and often hot), and cold winters, which determine a characteristic microclimate that differs from that of other parts of the region.

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2. Material and method

The methodological base of this study is that of the Life Cycle Assessment (ISO 14040: 2006). Within it there are a number of tools for the evaluation (ISO 2006a,b,c) of environmental impacts (Guinée et al. 2002; Haas et al. 2000), among which it is necessary to remember those present at the international level to calculate only emissions of greenhouse gases ISO 14067:2013, IWCC, OIV protocol GHGAP. However, beyond the life cycle approach, internationally, over the years, the OIV has developed at an international level the guidelines that provide for a new concept of wine making, precisely based on the principles of sustainable development. In 2008, the OIV therefore presented the Guidelines on sustainable viticulture, which provide a basis for implementing a concrete basis for the verification and the implementation of strategies for the sustainable management of vineyards.

2.1. Carbon Footprint

The Carbon Footprint (ISO 2013) is a methodology that analyses and quantifies the emissions of greenhouse gases from the production, use and end of life of goods or services. Its importance has grown considerably in the last ten years (Weidema et al., 2008; Gazulla et al., 2010; Schau et al. 2008; Schimdt 2009) due to the importance attributed to climate change by the media around the world.

in October 2011, the OIV has issued the RESOLUTION OIV-CST 431-2011, "General principles of OIV Protocol on the calculation of greenhouse gases for the wine sector", where all the rules to be applied to specific cases for the quantification of GHG emissions, both at product- and company level, are explained.

With reference to this protocol, the attachments are being finalised, which are called to define properly the criteria of application of the Protocol in the various operational contexts. The last contribution at international level to combat climate change, and more generally to environmental pollution, is led by the European Commission with the creation of the "Single Market for Green Product". The commission, within the logic of promoting and facilitating the production and marketing of sustainable products, has launched a number of pilot projects with the purpose of defining the rules of application of environmental certification to a number of products (including wine and olive oil). A set of guidelines will be presented then at European level and within two years for different supply chains, which will be the basis for the environmental certifications.

2.2. OIV guidelines for sustainable vitiviniculture

Sustainable viticulture is defined by the OIV (2008) as the "Global strategy on the scale of the grape production and processing systems, incorporating at the same time the economic sustainability of structures and territories, producing quality products, considering requirements of precision in sustainable viticulture, risks to the environment, products safety and consumer health and valuing of heritage, historical, cultural, ecological and landscape aspects". In these guidelines a set of criteria have been drawn up that constitute the basis for a coordinated and effective approach of the international wine industry to a sustainable environment. Within these, it is emphasised that noone should ever turn away from the three dimensions of sustainable development, but reaffirm the need to base sustainable activities on environmental risk assessment and that it must take into account these aspects: Selecting the location (for new vineyards/wineries); biodiversity; Selection of varieties (for new vineyards); Solid waste; Soil management; Energy use; Management of water use; Air quality; effluents; Use of neighbouring areas; Human resource management; agrochemical use.

3. Case study

The experimental work was carried out on farms Petrella, Vignale and Ferrai, located in the Valle Peligna.

The farm Petrella is totally located in the territory of Pratola Peligna (AQ), and consists of a total of 68 particles (10:26:00 he), out of which 03:24:00 include a vineyard. The vineyard varieties within the farm area include: Montepulciano d'Abruzzo, Trebbiano d'Abruzzo, Pecorino, Incrocio Manzoni, Syraz and Primitivo di Manduria. The vineyards are grown in rows (spurred cord) with a planting pattern that varies from 1 x 3.5 to 1 x 2.4 m. All the vineyards have irrigation drip, equipped with a fertigation system.

The farm Vignale is located in the territory of Raiano and Vittorito (AQ), and consists of 11 particles for a total of 6:16:00 ha, out of which 00.60.00 of Montepulciano d'Abruzzo farmed in rows of vines.

The farm Ferrari is located in the territory of Pacentro (AQ), and consists of 11 particles for a total of 7:57:00 ha, of which 00:20:00 (Montepulciano d'Abruzzo farmed in rows of vines).

Carbon Footprint

From the beginning of the project, all the data related to the production phases of the three firms were collected through a new orchard register created ad hoc. It was possible to record on this register all the data on carbon footprint and the other variables under study. Information was collected about:

- Localisation. Location data of firms in the local context, their position relative to the main infrastructure of the area and the composition of the various buildings, were collected.
- Equipment. Data were collected for mechanical machinery possessed and used by enterprises, fuel and any maintenance, data for the tools (flail, harrows, etc.) owned.
- Crops. Data for crops (as well as the vineyards) present in the company, the type, the extension and the eventual irrigation, were collected.
- Cultural practices: information was collected on the agricultural practices (processes that companies have made in their own land), fuel consumption, amount of mechanical work performed
- Treatments: information was collected regarding the treatments, products used, number of treatments performed, amount of product used, and fuel consumption to counter the operations of fertilisation.

The data collected (for both years) were subsequently inserted on an on-line tool, based on the standards mentioned above (EC 2011; IEA 2011, GHG Protocol 2010; Roy et al. 2010; Röös et al. 2010).

OIV guidelines for sustainable vitiviniculture

At the beginning of the project a full evaluation of companies based on the guidelines OIV was carried out and a document on the initial state was drafted. During the work, all of the aspects were evaluated separately and a series of measures to be implemented to improve the quality within the companies considered were developed.

4. Result and discussion

E All the data related to the production of wine in specified case were included in the software; they showed important points for reflection, in reference to the comparison between the interested companies that the production seasons detected.

Tab. 1 - Inventory data for the farm phase per 1000 kg of grapes

Process	**Input**	**Unit**	**Az. Petrella**		**Az. Vignale**		**Az. Ferrari**	
			2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014
Tillage	Diesel	L	11.79	11.79	7.15	7.15	9.31	9.31
	Fertiliser	Kg	NPK 15:5:5	NPK 15:5:5	NPK 10:12:7	NPK 10:12:7	NPK 15:5:5	NPK 15:5:5
Phytosanitary and fertilisation treatments	Quantity	Kg	56.50	50	77.5	77.5	68	68
	Pesticide	type	Bordeaux mixture. Mancozeb.	Bordeaux mixture. Mancozeb.	Mancozeb	Mancozeb	Bordeaux mixture Mancozeb	Bordeaux mixture Mancozeb
	Quantity	Kg	5.5	12.66	4.98	13.76	5.25	12.79
	Water	L	347.82	1217.39	328.134	1490.13	377.10	1370.56
	Diesel	L	4.17	9.73	4.292	8.91	4.87	10.12
Pruning and harvesting	Diesel	L	12.80	4.57	6.54	4.78	6.54	4.45
Transport of materials and products	Inputs transport to farm	tkm	4.67	5.69	6.72	6.72	5.93	5.93
	Grape transport to winery	tkm	1.451	0	2.020	0	7.345	0

Tab. 2 – Carbon Footprint

	AZ. PETRELLA		AZ. VIGNALE		AZ. FERRARI	
	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014
Grape harvested (kg)	11500	0	8000	0	10000	0
Wine produced (kg)	80.5	0	56	0	70	0
Emissions from agricultural phase (kg CO2/ha)	580	1175	495	976	475	990
Emissions form industrial phase (kg CO2/ha)	379	0	347		368	0
Total emissions (kg CO2/ha)	959	1175	842	1175	843	1175
Emissions per kg grape (kg CO2/kg)	0.102	∞	0.122	∞	0.099	∞
Emissions for wine (kg CO2/litre)	0.193	∞	0.236	∞	0.194	∞

4.1. Carbon Footprint

From the analysis of the microdata (not shown due to space restrictions) it can be seen that plant protection treatments are the most significant item in all companies. All companies under study apply a conventional management to the to the vineyard. As it was highlighted by Rugani (2013), it is not the plant protection products that determine the associated emissions' value, but the number of treatments performed (and thus the diesel fuel used and the amount of applied chemicals) that contributes approximately 50% of the total value. For this reason, the organic practices, even though not using chemical products, they use quantities of other products (Bordeaux mixture, etc.) in an amount being higher than (kg/ha) for each treatment and they often require more frequent treatments compared to what is normally expected in the organic practice.

On the contrary, fertilisation treatments contribute significantly to the greenhouse gas emissions in all case studies.

In the study of the two production seasons, it was noted that in 2013/2014 the adverse climatic conditions and the disease attacks have severely damaged the crop crop to the point of bringing the production to zero. Nevertheless, it was identified that in the previous year, the emissions related to the agricultural phase, and consequently to plant protection treatments and fertilisation processes were significantly lower. Indeed, this depends on the weather conditions and on the best practices that are not yet adopted by the companies under study.

Another factor to consider is that inherent energy efficiency of agricultural machinery used in the agricultural phase: tractors and related equipment have an average of 15-20 years. The data are particularly significant because the energy efficiency of machinery and increased work capacity (associated with the latest generation tractors) can ensure improvements (in terms of reduced emissions) up to 15% -20%. For the harvesting and transport phase, it was seen that both operations represent very low values from 2% to 10% of the total emissions of the agricultural phase. The variability depends mainly on the automation level (manual or mechanical) of the harvest and the amount of grapes carried by single trip to the winery. As far as the vinification phase is concerned, this is common for the three firms, because all three deliver grapes to the same winery. In the process of wine production, the main sources of GHG emissions are related to electric utilities (pumps, compressed air, refrigeration) and to the direct release of CO_2 from the must fermentation. However, this source is not included within the GHG balance because it belongs to the short cycle of CO_2 and therefore it is not accounted for. As far as the technological adjuvants are concerned, it can be said that their contribution is marginal, because the quantities used and their emission factors are low. With reference to the three farms, Petrella was found to have emissions greater than the others. An explanation of this fact can be found in a greater use of mechanical working of the soil and in the use during the collection phase of mechanical means in place of the manual collection. These factors imply an increase in emissions that can range from 7% to 22% depending on the energy efficiency of agricultural machinery used and on which operations are performed mechanically rather than manually (pruning and harvesting). Referring to other studies concerning the carbon footprint within the wine industry (Rugani et al.2013) it can be seen that the average value of GHG related to the production of a bottle of 0,75 l wine is about 1.91 kgCO2eq. The analysis of Rugani shows that this value depends quite equally on all stages of the life cycle, with some significant peaks for the agricultural and packaging phases. The result of the experiment in the Valley Peligna is in line with what was analysed by Rugani in his reviews on carbon footprint. Indeed, from the analysis of the data variance collected by Rugani, it can be noted that all GHG emissions values for each phase of the life cycle are subject to change by 50% for the packaging to a maximum of 194% for the end of life phase. This shows without any doubt the extreme importance of factors related to the methods of vineyard management and other factors such as the end of life (in this area not only the processes of waste treatment in a particular nation are included, but also the type of packaging used for the case of wine).

4.2. OIV Guidelines

Within the investigated context, the principles provided in OIV CST 1-2008 were applied. The field data collected, the holding files and the country notebooks were analysed and processed and a critical review of them was performed.

The aspects considered are those provided by the guidelines: Selecting the location (for new vineyards/wineries); biodiversity; Selection of varieties (for new vineyards); Solid waste; Soil management; Energy use; Management of water use; Air quality; effluents; Use of neighbouring areas; Human resource management; Agrochemical use.

From the analysis performed on these aspects in three different cases, operating margins for the improvement of the different issues considered were found to be potentially large, both in the short and long term, however, for several issues improvements are difficult to be achieved. For example, the choice of location, air quality, use of neighbouring areas, and in part the selection of varieties appear as elements whose management and improvement can be evaluated and achieved only in the long or very long term. Other aspects such as biodiversity, human resource management, the effluent, etc., can be managed and can be improved in the short term and therefore should be taken into greater consideration. The companies implemented a strategic plan to improve these issues. The evaluation of these aspects in the second year has shown a marked improvement in the overall performance (improved efficiency in the use of mechanical machinery, rational use and not scheduled for pesticide treatments).

5. Conclusion

The application of these instruments to concrete case studies has allowed for several considerations for both the optimisation of the supply chain of wine and the practical application of the two methodologies to be delineated.

Furthermore, the "hot-spots" in the supply chain were identified:

- The agricultural phase remains the most impacting one for the GHG emissions and for the improvement of the OIV Protocol. Proper management of agricultural practices and a reduced use of: plant protection treatments, fertilisation processes and no tillage would improve the general conditions of the vineyard;
- The energy efficiency of the mechanical equipment (tractors and machinery for the harvest and pruning) is a key factor to control why this improvement could allow for a substantial reduction of the emissions (10% -20%);
- Causes that act as multipliers for the identified impacts : i) the climatic conditions that determine the number of pesticide treatments, ii) technological factors that affect the efficiency of operations in the vineyard and in the industrial phase, iii) soil conditions that determine the amount of fertilisers to be used in the agricultural phase for the maintenance of the yields;

With regard to the methodological aspects related to the application of Carbon Footprint, some issues have to be noted:

- lack of specific data (LCA) with an appropriate level of detail. Difficulties have been identified in recovering data, in particular for the industrial stage. Even at the farm level, some difficulty in obtaining data and a lack of their quality were found. The request for greater accuracy in data collection was often seen in a negative way by farmers.
- carbon storage in the soil and in the vineyard. There are two issues of extreme importance, for which there are many ongoing scientific studies. However, it is still difficult to measure the storage in a precise way;
- regarding the OIV resolution, not all attachments have been yet published for Carbon Footprint, therefore leaving a gap in terms of clear and correct application of the methodology at an international level.

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