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"La viticultura de precisión en la mejora de la calidad del vino"

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Ponencias

"La viticultura de precisión en la mejora de la calidad del vino" JORNADA INTERNACIONAL VINTAGE

ANALYSIS AND HISTORICAL RETROSPECTIVE OF PRECISION VITICULTURE

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ABSTRACT: Since the beginning of technical precision viticulture in combination with the appearance of sensors and monitors performance, particularly in Australia and the United States back in 1999, there have been major advances in the analysis of vineyard variability and in the optimization of grapes production. Considering the last decade, wireless technologies have been increasingly applied in precision agriculture. In particular, wireless monitoring systems have been used in precision viticulture in order to understand vineyard variability, and therefore suggest appropriate management practices to improve grapes quality. Precision viticulture has been developed according to consumer needs, environmental conditions and technological advancement.

Keywords: Precision viticulture, Precision agriculture, Vineyard, Technology

1. INTRODUCTION

It has been well recognized that there is an increasing need in agriculture to adopt site-specific management practices because of economic and environmental pressures (Frogbrook and Oliver, 2007; Ortega *et al.*, 2003). Moreover, during the last fifteen years many new technologies have been developed for, or adapted to, agricultural use (Tisseyre and Taylor, 2004). For example, part of the information gathered with this technology could enhance interpretation of plant growth and improve site-specific management practices (Zaman and Salyani, 2004).

Nevertheless, this management requires accurate knowledge about the spatial variation of soil properties within determinate fields. In viticulture the understanding of the nature, extent and causes of vineyard variability may help grapegrowers and winemakers to use precision farming tools to improve management practices such as irrigation, fertilization, pruning and harvesting (Bramley and Lamb, 2006).

PA (precision agriculture) may be defined as a management strategy that uses information technologies to bring data from multiple sources to bear on decisions associated with crop production. Under the scope of PA new terms has been produced e.g. PV (precision viticulture) (Li and Chung, 2015). PA innovation, technology and the consequent extended adoption by other areas are still an issue of interest and discussion for future direction of PA and PV implementation in

different countries and regions. Also, new developments in computer hardware and software, global navigation satellite systems (GNSS), canopy sensors and remote sensing offer opportunities for fast and inexpensive crop controls (Zaman and Salyani, 2004; Llorens et al., 2010).

PV is a production system that promotes variable management practices within a field according to site conditions (Morais et al., 2008). PV is recommend to simple or very unique fields that poses very specific challenges, mostly due to the topographic profile, pronounced climatic variations, variability of grape and complex soil characteristics (Morais et al., 2008; Matese et al., 2009). Grape harvest and disease predictions as well as the assessment of the grape value are currently left to the grape growers, without the help of decision-support mechanisms (Matese et al., 2009).

Considering that the main goal of PV is to simultaneously maximize both guality and yield production (Morais et al., 2008; Matese et al., 2009), PV needs an array of sensors that monitors the environmental, climatic and physiological parameters, factors that allow, in an adequate combination, to achieve high efficacy and efficiency values (Morais et al., 2008; Llorens et al., 2010).

This paper will present a brief review of the history of PV and the application of new related technologies. It focusses, in its first section, in climate, soil, and plant quality monitoring systems. In the following section, some current PV applications, tools and methods applied to improve the production system which takes into account fertilization, irrigation, pruning and harvest are also presented.

2. HISTORY

Traditionally, viticultural practices have been performed in the vineyards in a constant manner. The same intensity or dose in operations such as pruning, fertilizing, phytosanitary treatments, irrigation, etc., has been applied regardless of the exact location within the vineyard (Arno et al., 2009).

However, under the arguments of how PV can be positively used by vine growers and wine makers, McConnell et al. (1983) and Giles et al. (1989), studied the use of electronic devices to measure crop dimensions and pesticide application. Both studies concluded that control based upon target measurement, rather than simple target detection resulted in substantial increases in savings of applied spray liquid.

In further research related with treatment efficiency Solanelles et al. (2002) reported the effect of different shapes, sizes and foliar densities in tree crops during the same growing season and found that a continuous adjustment of the applied dose rate is required to optimize the spray application efficiency and reduce environmental contamination. Thereby, the importance of the information, equipment or people geolocation within vineyards plays a critical role, highly influencing grape and wine production (Tisseyre and Taylor, 2004).

Despite the relative infancy of PV, many research projects exist in practically all the significant wine production areas of the world; including, France (Tisseyre et al., 2005; Goutouly and Gaudillière, 2006, Bobillet et al., 2005), Spain (Arno et al., 2005), U.S.A (Johnson et al., 2003), Chile (Ortega-Farias et al., 2003; Ortega et al., 2003; Best et al., 2005), South Africa (Strever, 2004), New Zealand (Pratt et al., 2004) and Australia, country where the basses of PV seems to be most advanced (Lamb et al., 2004; Bramley and Hamilton, 2004; Taylor et al., 2005).

Some of the current research projects are aimed to develop and analyse sensing systems, such as biomass or leaf area index sensors, yield sensors and quality sensors to provide accrued information, a very desirable goal to achieve in viticulture. Nevertheless, the appearance of other projects to quantify the within vineyard variability in combination with data processing tools to assist winegrowers in decision-making, are also possible now with the use of PV. With a combination of these technologies and methodologies winegrowers will thus be able to improve and optimise the production process by taking into account technical and economic management aspects as well as environmental concerns.

An example of such an improvement is the site-specific management with the objective to optimize fertilizer applications or water use efficiency in irrigated vineyards (Tisseyre and Taylor, 2004).

3. APPLICATION OF PRECISION VITICULTURE

3.1. Climate monitoring

Weather station

The climate is one the variables that influences annual variability. Moreover, microclimates within vineyard are one of the reasons of plot variability. Hail, drought or rainfall can represent a big threat for grapes guality also highly influencing diseases development. Weather stations allow to measure climatic factors such us temperature, relative humidity, UV ray, wind direction, wind strength and evapotranspiration. Predictive models are then built using the recorded information. Winegrowers have thus available valuable information that can be used in the definition of the irrigation regime and/or phytosanitary treatments.



Figure 1 | Weather station components. Source: www-k12.atmos.washington.edu

Application to phytosanitary treatments

The application of predictive models of disease, based on climate records appears as a very useful tool in modern crop management. First of all it allows a reduction in the number of pesticide treatments to apply since it provides a better monitoring of the diseases cycles and secondly because it permits to use less aggressive preventive treatments which are more respectful to the ecosystem balance than curative ones. Finally it is also important the selection of a suitable prediction model always based on the climatic characteristics of the area.

Application to irrigation

In the same way as phytosanitary treatments, irrigation programs can be based on rainfall accumulated historical analysis and also on weather forecasting in the area over a certain period of time. This can be of high importance for irrigation regime decision-making.

3.2. Soil monitoring

The variability of a vineyard is linked to the variability of the complex soil composition. Soil properties can vary with space, time and physical and microbiological reactions. Soil characterization can be complicated and expensive. This is probably the main reason why almost every vineyard has been planted without a study of soil variability. This thus leads to heterogeneous plantations together with heterogeneous quality of the grapes within a plot. Soil variability studies might help to rectify this problem by measuring vigour, fertility, yield, and soil characteristics at different sample spots. The transcription of the recorded information into maps will help to identify homogeneous crop units. Once plot variability is known treatments such us irrigation, nutrition and canopy management could be adapted accordingly to each unit fitting the exact needs of each location.

Mapping spatial variability

Soil properties can be measured based on the soil electro-magnetic properties. The apparent soil electrical conductivity (EC_) (Corwin and Lesch, 2005; Samouellian et al., 2005) is thus measured using this technology. This parameter is strongly correlated with the texture of the soil, the water retention capacity, the organic matter content, the salinity and the depth of the soil. In practice, sensors are placed on a tractor connected to a GPS (global positioning system) which does continual measurements. All this information can also be used in the spatial variability maps drawing. Three types of EC_a sensors are available:

- Electrical Resistivity (ER) sensors. Utilise invasive electrodes to provide information on the form of subsurface heterogeneities and their electrical properties (Samouellian et al., 2005). Commercial examples of ER sensors include the Automatic Resistivity Profiling device (ARP) and the Veris 3100 (Veris Technologies, Salina Kansas, USA).
- Non-invasive Electromagnetic Induction (EMI or EM) sensors. Commercial examples of EMI sensors include the EM-31 and EM-38 soil conductivity meters (Geonics Ltd, Mississauga, ON. Canada) and DualEM systems (DualEM, Milton, ON, Canada).
- Time domain reflectometry (TDR) sensors.

ER and EM technologies are largely used in viticulture. Barbeau et al. (2005) used ER to compare the effect of grass cover on soil water distribution. Taylor (2004), Best et al. (2005) and Bramley (2005) have used ECa information to delineate within-field soil zones. However the distortion of the values caused by trellis wire, especially for vineyards with small row spacing (<2.5 m) has been identified as the main drawback of this approach (Lamb et al. 2005).



Figure 2 | a. Veris 3100. Source: www.ext.colostate.edu.



Figure 2 | b. EM-38 Geonic. Source: www.lb-track.cl

Figure 3 shows the soil variability within the vineyard. High EC₂ indicates dense clay while low EC₂ shows light deep alluvial soil. This map clearly delimits different areas and could be analysed in combination with the vigour and yield map in order to investigate grapes variability.

Application to fertilization

EC, maps facilitate soil analyses of organic mater content, nutritive elements, water retention capacity and root depth. It is possible to do the sampling according to the different more relevant delimited areas. Soil mapping helps in the definition of a fertilization plan, using the information provided from the delimited crop units and the plant needs.

Application to irrigation

Plant water supply monitoring plays an important role on grape production. In viticulture, low water supplies are desired. Initially the measurement of the water present in the soil at this order of magnitude was an issue. Using low-frequency resonance measurements, the humidity of the soil can be monitored and the available water at any physiological status can be known. This method, combined with the climatic records, enables decision-making which prevent from quality loss due to excessive irrigation.



Figure 3 | EC, map. Source: Montpellier SupAgro, 2008.

3.3. Plant monitoring

Site-specific plant monitoring is nowadays widely extended in grape production. Especially vigour and canopy management are monitored using different types of sensors.

Earth remote sensing

Earth remote sensing collects data with sensors positioned in the air or in earth orbit. In precision viticulture satellite highresolution pictures (1.85-3,2 m/pixel) are used (Ikonos, QuickBird, WorldView-2, etc.). Moreover, pictures taken by small planes or drones with multispectral cameras (0,2-0,5m/pixel) or aerial infrared photography contribute heat maps drawing. This data collection combined with a geographic information system (GIS) provides useful information by means of real data. The use of earth remote sensing data often constitutes a relevant and low cost information source to perform vigour zoning at a within-field level.

Aerial and satellite images are generally processed to estimate vine vigour with vegetative indices, such as Normalised Difference Vegetative Index (NDVI), Plant Cell Density (PCD) and Photosynthetic Vigour Ratio (PVR) (Lamb and Bramley, 2004). In remote sensing, vigour is understood as a combination of plant biomass (vine size) and photosynthetically active biomass (PAB) (=photosynthetic activity) (Bramley, 2001). These indexes therefore allow for the identification and delimitation of different vigour areas where for example vigorous vines are characterised by larger and denser canopies than lower vigour vines. Many authors have shown relationships between NDVI and vine parameters including Leaf Area Index (LAI) (Johnson et al., 2003), annual pruning weight (Dobrowski et al., 2003), or other vine parameters (Lamb et al., 2004) at a within vineyard level. However, although zones based on these indexes correspond to more or less vegetative crop growth, and even performance, the correlation between the guality of the grapes and the different areas delimited is not always achieved (Santesteban et al., 2010).

However, the combination of vegetative indexes with others variables such us fertility maps, vegetative development maps (number of buds), fruit loading, pruning weight, etc. can counterbalance this limit of multispectral remote sensing (Martínez-Casasnovas et al., 2012).

The use of hyperspectral and thermal remote sensing represents a jump to a better determination of physiological indexes and hydric status of the plant, with much more precision. Recent studies show the use of physiological indexes calculated from hyperspectral images as possible indicators to assess the quality of the grapes in vineyards affected by iron deficiency (chlorosis) (Martin et al., 2007; Meggio et al., 2010), or by water deficit (Pons et al., 2013). Thus, the increase of carotenes and anthocyanins which occurs in water stress or micronutrient deficiencies (iron), and can be detected from hyperspectral index, is a good indicator of the grape phenolic maturity (Meggio et al., 2010). Moreover, the estimated water deficit through indices such as the so-called Water Index, better predicts the composition of grapes in terms of sugar content and acidity vegetation indices (Pons et al., 2013).

Although scientific advances have been observed in the last years, hyper spectral and thermal imaging application development on a commercial scale is still incipient. Despite its limitation to predict grape quality, multispectral maps are used for decision-making in precision viticulture.

Proximity sensing

New systems have recently been developed to analyse vigour using sensors for pedestrians or vehicles combined with a positioning system.

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