Computers and Electronics in Agriculture 127 (2016) 15–25

Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag

Original papers

Exploratory study on vineyards soil mapping by visible/near-infrared spectroscopy of grapevine leaves

R.N.M.J. Páscoa [a], M. Lopo [a], C.A. Teixeira dos Santos [a], A.R. Graça [b], J.A. Lopes [c,*]

[a] REQUIMTE, Laboratório de Química Aplicada, Departamento de Ciências Químicas, Faculdade de Farmácia, Universidade do Porto, Rua de Jorge Viterbo Ferreira, 228, 4050-313 Porto, Portugal

[b] SOGRAPE Vinhos S.A., Departamento de Investigação e Desenvolvimento, Aldeia Nova, 4430-852 Avintes, Portugal

[c] Research Institute for Medicines (iMED.ULisboa), Faculdade de Farmácia, Universidade de Lisboa, Av. Prof. Gama Pinto, 1649-003 Lisbon, Portugal

ARTICLE INFO

Article history:
Received 28 December 2015
Received in revised form 19 April 2016
Accepted 30 May 2016

Keywords:
Near infrared spectroscopy
Soils
Vineyards
Leaves
Precision agriculture
Chemometrics

ABSTRACT

This work demonstrates the possibility of discriminating vineyard soils through the non-destructive and in-situ visible/near infrared monitoring of leaves. A portable Vis/NIR spectrometer was applied for monitoring *in-situ Vitis vinifera* leaves in vineyards of two wine regions in Portugal in the maturation period. Leaves reflectance spectra of different grapevine varieties planted in different vineyard locations (distinct soil taxonomic types) were analyzed by principal component analysis and partial least squares discriminant analysis. Soil discriminant models based on leaves Vis/NIR spectra yielded for both vineyards approximately 95% correct soil taxonomic predictions. This methodology was then applied to monitor all plants within a 0.3 ha vineyard block in the Dão vineyard resulting in a highly detailed soil taxonomic map built exclusively from leaves Vis/NIR spectra. A comparison with the existing soil map proved that the NIR spectroscopy based estimation was very similar. Even though further studies are needed, namely in different maturation stages and other geographical regions, to ensure reliability of this technique, results in this work showed that it can be used as an additional auxiliary tool for obtaining vineyard soil maps. Its main advantages over pedological reference procedures are speed and cost efficiency analysis.
© 2016 Elsevier B.V. All rights reserved.

1. Introduction

The emergence of precision viticulture is based on the need for a more detailed monitoring and control of the quantity and quality of the production in a vineyard. Precision viticulture involves methodologies able of site-specific monitoring and management (Mazzetto et al., 2010) and is based on the assumption that productivity within vineyard blocks can be highly variable. Soils play a major role in this variability (White, 2009) together with other factors such as latitude, topography, climate (temperature, frost, humidity, rainfall, sun exposure), diseases (powdery mildew, downey mildew, phylloxera), grapevine variety and viticulture practices (Jackson and Lombard, 1993). Vineyard soil characterization is of the utmost importance since soils play a major role in vine behavior, grape quality and ultimately wine sensory properties (Bodin and Morlat, 2006). Since vineyard soils have a strong influence over grapevine leaves elemental composition, knowing their physical characteristics and chemical composition is very important for an efficient management (Peuke, 2009). This characterization is an interesting support tool for the cultivation/replantation of new vineyards with the objective of increasing the quality and yield of produced grapes. However, the actual situation shows that in most vineyards around the world, winemakers still do not take into account this particular knowledge due the lack of customary resentment that new technologies normally encounter in a traditional industry. Due to lack of information, fear of investment in new technologies and deeply rooted habits, vineyards are usually divided into blocks, each block having typically a single grape variety. Additionally, in many situations, soils with different characteristics may coexist in the same block. With this type of configuration, the quality of grapes harvested from the same block will not be the same. Since each vine variety has specific growth requirements, the same variety planted in different soils will grow differently. This is demonstrated by grapes analytical parameters and yield. Consequently, there is a demand for the development of faster, more reliable and cost effective techniques able to characterize vineyard soils that can be used efficiently as a viticulture support tool. Near infrared spectroscopy (NIRS) is a candidate for this purpose since it presents all the aforementioned

* Corresponding author at: Research Institute for Medicines (iMED.ULisboa), Faculdade de Farmácia, Universidade de Lisboa, Av. Prof. Gama Pinto, 1649-003 Lisbon, Portugal.

E-mail address: jlopes@ff.ulisboa.pt (J.A. Lopes).

http://dx.doi.org/10.1016/j.compag.2016.05.014
0168-1699/© 2016 Elsevier B.V. All rights reserved.

characteristics. Near infrared radiation is influenced by combinations and overtones of fundamental vibrational transitions, essentially of C–H, N–H, O–H and S–H bonds (Workman and Weyer, 2008). A major advantage of NIRS is the possibility to obtain spectral fingerprints without sample processing. Another important feature of this technique is that it can be incorporated in remote sensing devices or used to obtain multispectral images (Govender et al., 2009). Spectral measurements can be made in plant leaves, either at-line in laboratory or in-situ at the vineyard, or by remote devices (remote sensing).

The determination of chemical elements of vineyard soils by NIRS has been reported in several recent studies. (Salazar et al., 2012) evaluated cobalt contamination in vineyard soils with NIRS demonstrating the feasibility of the method for detecting concentrations over 1 g-Co kg^{-1} of soil sample. (Cozzolino et al., 2013) measured total nitrogen, organic carbon, potassium, sulfur, phosphorous, pH and electric conductivity *in-situ* with a portable NIRS instrument in three different wine regions in Australia. The method was able to discriminate soils and a good linearity for all elements/properties was obtained except for potassium and organic carbon. The first study attempting to use Vis/NIRS directly in grapevine leaves was performed by (Steele et al., 2009) with the objective of estimating the anthocyanin content. The best results were obtained using the green and red regions for the anthocyanin reflectance index and green, red and NIRS regions for the modified anthocyanin reflectance index. In 2012, two commercial optical devices (GreenSeeker RT100 and Crop Circle) were tested for detecting different levels of grapevine downy mildew symptoms in Cabernet Franc leaves. However, this method was not applied *in-situ* (Calcante et al., 2012). Off-line collected hyperspectral images of grapevine leaves in the range of 380–1028 nm were used to classify Tempranillo, Grenache and Cabernet Sauvignon varieties (Diago et al., 2013). NIRS as a remote sensing tool has been extensively used for the characterization of spatial distribution of vine vegetation, often through the estimation of the NDVI index (Drissi et al., 2009; Goutouly et al., 2006; Mazzetto et al., 2009). (Mazzetto et al., 2010) tested a remote sensing system for monitoring disease (*Plasmoparaviticola*) spreading in vineyards. This system included two GreenSeeker RT100 sensors, a DGPS receiver and ultrasonic sensors. The obtained results were comparable to the real vine phytosanitary status (Mazzetto et al., 2010). The determination of iron deficiency chlorosis, through carotene and anthocyanin pigments content estimated with hyperspectral imaging data, allowed the design of maps pinpointing specific harvesting regions that have the desired wine properties (Meggio et al., 2010). Remote sensing was used to estimate leaves anthocyanin content using Vis/NIR hyperspectral imaging (Qin et al., 2011). More recently, (Ciraolo et al., 2012) used multispectral images from different spectral regions (visible and NIR regions) to map the evapotranspiration of leaves on a Sicilian (Italy) vineyard. (Saiz-Rubio and Rovira-Mas, 2012) mounted a UV/VIS/NIR camera on a conventional tractor to estimate vine vigor achieving the best results using the NIR spectral region. On a similar note, (Kodaira and Shibusawa, 2013) used VIS–NIR reflectance spectroscopy to estimate soil properties (including moisture, organic matter, pH, electrical conductivity, among others). (Stamatiadis et al., 2006) also used device to estimate biomass production, pruning weight, yield, Brix, phenolic and anthocyanin contents.

This work intended to investigate the potential of Vis/NIR spectroscopy to characterize soils based on direct in-situ measurements of vine leaves, enabling the estimation of soil variability maps in a fast and simple approach that when compared with currently existing methods. This approach involves only in-situ and non-destructive analyses. For this task, a portable Vis/NIR spectrometer spanning a 350–2500 nm range was used to monitor several blocks in two vineyards of two Portuguese wine regions (Dão and Alentejo). This approach is intended to provide another decision support tool for winemakers, enabling delimitation of harvesting zones and planning of grapevines plantation or replantation. To the best of our knowledge this is the first time Vis/NIR spectroscopy is used on vineyard leaves with the purpose of mapping soil taxonomic types.

2. Material and methods

2.1. Vineyards monitoring

Two vineyards, property of SOGRAPE VINHOS SA, in two different wine regions in Portugal were selected: *Quinta dos Carvalhais* (Mangualde, 40.556721–7.787247) in the Dão Wine Region (center of Portugal) and *Herdade do Peso* (Vidigueira, 38.141579–7.677813) in the Alentejo Wine Region (south of Portugal) (Fig. 1). Soils in these vineyards were previously characterized through pedological methods in the scope of a European Union (EU) project (Pessanha and Graça, 2011) and named according to the international soil classification system (*IUSS*, 2014). Table 1 compiles the existing taxonomic types of soils in both vineyards together with soil texture information for the first two horizons (*IUSS*, 2014). Vineyards are divided in numbered blocks, each containing a single *Vitis vinifera* cultivar. Several monitoring spots were identified with the objective of analyzing leaves spectra variability within the same grape variety, planted on different soil taxonomic types. The rationale for vineyard spots selection was based on the existence in the vineyards of grapes of the same variety grown on soils with distinct characteristics (4 varieties in Herdade do Peso and 5 varieties in Quinta dos Carvalhais). For these varieties, sampling spots were defined in locations which have only one soil taxonomic type (Fig. 1). Table 2 summarizes the characteristics of the selected monitoring spots: 14 spots in *Quinta dos Carvalhais* and 15 spots in *Herdade do Peso*. At each defined sampling spot, a total of twenty leaves in five different plants were monitored (four monitored leaves per plant). Monitoring in *Herdade do Peso* (with an average temperature of 15–17.5 °C, precipitation 500–800 mm and no significant altitude shift) and *Quinta dos Carvalhais* (with an average temperature of 14–16 °C, precipitation 1100–1600 mm and no significant altitude shift) was made on 2012-07-29 and on 2012-08-31, respectively (ripening stage shortly after the veraison period). A total of 300 and 280 spectra were collected in *Herdade do Peso* and *Quinta dos Carvalhais*, respectively (Table 2). Additionally, three leaves of all plants of a 0.3 ha block in *Quinta dos Carvalhais* were monitored (total of 1200 spectra). The goal was the validation of this methodology, allowing the generation of a detailed soil map of that block, based exclusively on Vis/NIR spectral measurements. Moreover, a soil sample beneath each plant of this entire block was also collected (approximately 26 samples per row in a total of 15 rows) to confirm if the detailed map is consistent with the pedological map.

2.2. Spectral acquisition

Near infrared leaves spectra (Fig. 2) were acquired using a FieldSpec 4 Wide-Res (ASD Inc, Boulder, CO) in diffuse reflectance mode spanning the 350–2500 nm range. The spectral resolution and sampling interval were 3 and 1.4 nm for the 350–1050 nm spectral range and 10 and 2 nm for the 1000–2500 nm range, respectively. The system incorporated a reflectance contact probe (Hi-Brite, ASD Inc., Boulder, CO) with a measurement surface area equivalent to a 10 mm diameter circle, enclosing a halogenous light source (Fig. 2). A background was taken every hour with a Spectralon® disk (ASD Inc., Boulder, CO). Leaves were measured in diffuse reflectance mode directly in the plant (*in-situ*) with no cleaning process

Download English Version:

https://daneshyari.com/en/article/6540029

Download Persian Version:

https://daneshyari.com/article/6540029

Daneshyari.com