MATURITY GRAPE INDICATORS OBTAINED BY MEANS OF EARTH OBSERVATION TECHNIQUES

J. Sanz and J. L. Casanova

Remote Sensing Laboratory, LATUV, University of Valladolid, Spain.

A. Romo and S. Fraile

Deimos Imaging S.L.U., Boecillo Technological Park, Valladolid, Spain.

ABSTRACT

Wine producers often need to buy grapes from growers. A good selection of grapes allows obtaining the desired wine quality. This paper presents a procedure to obtain by means of earth observation techniques indices and parameters used in the Spanish vineyards to monitor the state of the grapes. In this way is possible to monitor the ripeness of the grapes or the best time to harvest in such a way that growers can get the highest quality grapes, while producers of wine can select the most appropriate characteristics for the type of wine they wish to produce

The work has been performed using IKONOS images and field data. The field data obtained regularly by chemical analysis are sugar, pH, total acidity, tartaric acid, malic acid, total anthocyanins, anthocyanins easily removable and weight of 100 berries. These data have been studied in relation to various indices obtained by remote sensing: NDVI, LAI, Green / NIR reflectances and so on, having obtained correlation indexes r^2 between 0.7 and 0.9.

As a final result of this work, the vineyards are classified into three categories using remote sensing techniques, according to the level in each one of them of the measured quantities: below average, on average and above average.

Keywords: Vineyards, remote sensing, grape maturity, anthocyans.

INTRODUCTION

The European wine sector is of great importance because of the economic value generated as the population it occupies, and the role it plays in environmental conservation. The largest area of vineyards is in Spain, with more than 1,100 kha followed by France and Italy with around 800 kha. By comparison, USA has around 400 kha of vineyards. Nevertheless, France and Italy produce 20% each of the world wine production, Spain 15 % and USA a bit less of 10 %. In summary the EU produces two thirds of the 160,000 kilo hectoliters of world production, and the rest of the world, mainly USA, Argentina, Chili and Australia, one third.

By type of wine, France ranks first as a producer of quality wines, with 23.5 million hectoliters, compared to 14 in Italy and 13 in Spain. With respect to the second quality wines, the Italian production is of 15 million hectoliters, the French is of 12 million and the Spanish is of 2.5 million. And finally, for table wines, the less quality wines, Spain and Italy are in the lead with 18.9 and 18 million hectoliters respectively while France in turn produces only 1.8 million hectoliters. It is of course that the Spanish and Italian wine producers are working hard to raise the quality wines production.

Is in this scheme where our work is. The classical paper (Hall et al., 2002) shows an extensive review of remote sensing applications in viticulture: it analyzes seventy references ranging from mid seventies to early 2000's. From this time, many others authors have tried to analyze the quality grape by remote sensing methods: we can mention the paper from Martin et al. (2007) in which, using a CASI hyperspectral sensor, they showed the relationship between chlorophyll a+b concentration in leaves (C_{ab}) and grape quality parameters in vineyards.

Other very interesting paper (Lamb et al., 2004) analyzes the links between remotely-sensed descriptors of vine canopy vigour at different phonological development stages and subsequent measurements of total phenolics and colour in harvested Cabernet Sauvignon grapes. The generic term "phenolics" include several compounds as anthocyanins, tannins and flavonols, responsible of so important wine characteristics as taste and colour.

Finally, we can mention (Serrano et al., 2012). In this paper an extensive analysis of berry attributes is carried out, concluding the authors that NDVI is a good indicator to characterise the effects of water availability on yield while the Water Index, an indicator of stomatal aperture, provided reliable estimates of titratable acidity and maturity index in rainfed vineyards.

MATERIAL AND METHODS

The study was carried out on a commercial vineyard, Real Sitio de La Ventosilla, located at the DOC Ribera de Duero, at 42º42' N, 3º48'W and 815 m high. The analysis was conducted on two different vineyards, called "Pago La Mina" and "Pago de El Hoyo Dornajo", covering around 150 ha. The clay loam soils with a certain percentage of limestone are ideal for aging wines.

These "pagos" have 36 individual parcels, of different sizes, with Tempranillo and Cavernet Sauvignon grapes. The production accepted by the Regulatory Council of the DOC is up to 7000 kg/ha, but in order to preserve the high quality of these wines, harvest never exceeds 3000 kg/ha. The produced wine is a high quality wine called "Prado Rey" made on different classes: Reserva, Gran Reserva, Elite etc.

During the last months before harvesting, regular chemical analysis of grapes are carried out. The analyzed compounds are shown in the next table:

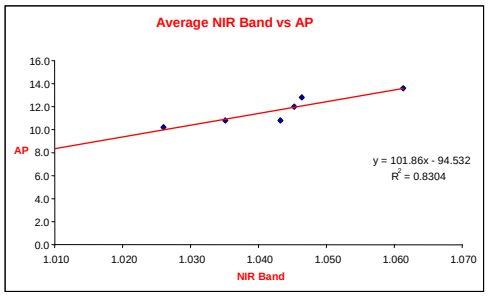
Table 1.- Analyzed grape compounds

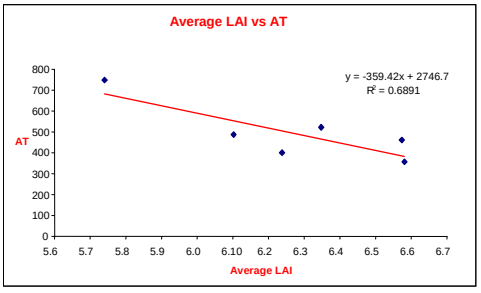
ATT	Total acidity on tartaric
ºAP	Probably alcoholic degree
AFE	Anthocyanins easily removable
AT	Total anthocyanins
MAL	Malic acid
P100	Weight of 100 berries
AZ	Sugar
IM	Maturity index
IB	Kindness index
IC	Colour intensity

These analyses were carried out on a regular 10-days basis. During the measurement period two IKONOS images were obtained covering the "pagos". The multispectral IKONOS images have four bands: Red, Green, Blue and NIR, with a pixel dimension of 4x4 sqm. (http://www.geoeye.com/). Different relationships were tried between the chemical compounds and several data coming from the IKONOS images, such as NDVI, LAI, reflectance etc. The obtained results are shown in the next paragraph.

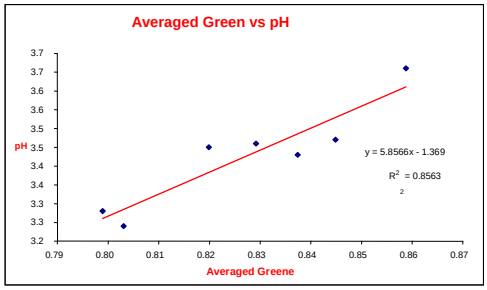
RESULTS

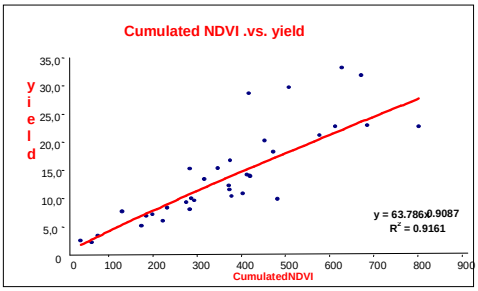
The points shown in the next figures correspond to averages values over different parcels: both, the measured values in the field and those coming from the IKONOS images are average values over a parcel. As we can see in these two graphs, the ºAP, Probably alcoholic degree, is directly correlated to NIR intensity, while the AT, Total anthocyanins, is inversely linked to LAI.



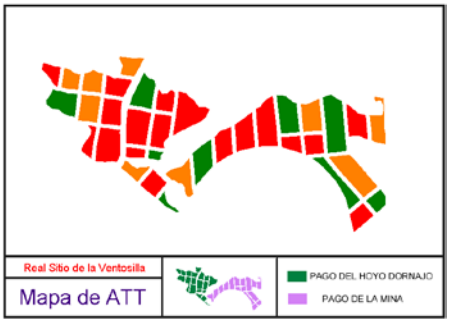


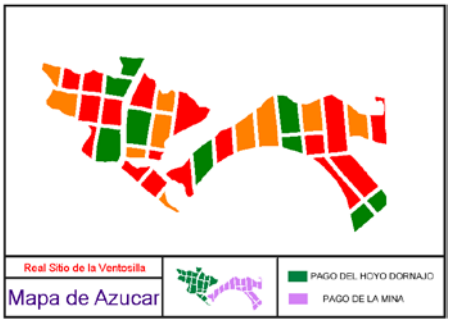
The next two graphs shown the relationship between the average green band intensity and the pH. The relationship is positive having a good correlation coefficient R^2 of 0,86. The right hand graphs shown the correlation between the cumulated NDVI and the parcel yield, with a better correlation coefficient of 0,91.



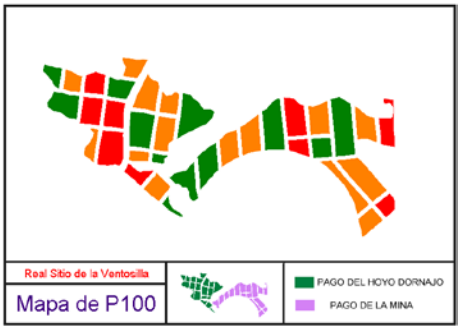


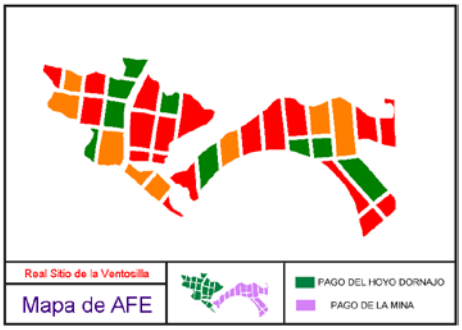
By means of the obtained relationships, it was possible to classify the different parcels into three categories for each one of the measured compounds: over the average value, on the average value and below the average value. In this case the average value is that from the Pago. Using a very simple colour scale, green, orange and red for each one of the three categories, it was possible to classify the different parcels. These images are an example of ATT, total acidity on tartaric and AZ, sugar.





The P100 map, the weight of 100 berries or the AFE map, anthocyanins easily removable, look similar to the previous maps, with an heterogeneous distribution of P100 and AFE values.





From these maps is easy to see the inhomogeneity of both Pagos. The Pago La Mina, in violet colour, has different parcels with higher and lower values than its

average value. The Pago Hoyo Dornajo, in green, has exactly the same situation. That means that the wine makers must be extremely careful when they select the grapes from different parcels due to unexpected inhomogeneities between parcels of the same Pago.

CONCLUSIONS

The found relationships between values coming from earth observation and those was coming from a field campaign, clearly shown the possibilities of remote sensing for evaluating the characteristics of vineyards. This fact could be used by wine makers that need to buy grapes from others vineyards, because using remote sensing could give them the possibility to know a priori the characteristics of the different grapes and to better select the type of grape adapted to their necessities.

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