CONVERSION TO MECHANICAL MANAGEMENT IN VINEYARDS MAINTAINS FRUIT

ARE SATELLITE IMAGES RELEVANT TO MANAGE VINEYARD FERTILIZATION CONSIDERING DIFFERENT REGIONS AND VARIETIES?

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Abstract:

Context and purpose of the study - Currentenvironmental, ecological and economic issues require a better vineyard production management. In fact, a poor use of fertilizing could lead to harmful impact on environment. Another issue concerns the cultures themselves which couldn't use fertilizers efficiently, leading to a loss of income or too much expense for farmers. Presently, estimation of fertilization's needs is realized by the laboratory analysis of leaves selected through a random sampling. The present study aims at optimizing fertilization's management by using a map of biophysical parameters estimated from satellite images.

Material and methods - Since 2016, experiments are carried out in three vineyard regions of France on three grapevine varieties (Merlot, Cabernet Franc and Merlot). The objective is to test if biophysical parameters or vegetation indices could be used to manage fertilization. Around ten plots in each region were studied. Leaves were sampled around the veraison period. Laboratory analysis were made to determine various parameters such as nitrogen, phosphorus and potassium content of leaves. Spot and Sentinel 2 satellite images were taken during the same period with a spatial resolution from 1.5m/pixel to 20m/pixel. A radiative transfer model was used to calculate biophysical parameters, including leaf area index (LAI), green cover fraction (Fcover), and chlorophyll content estimated in leaf (CHL). First, principal component analysis (PCA) were made to better understand the data distribution. Then, links between leaves components and biophysical parameters or vegetation indices were determined using simple and multiple linear regression.

Results - Differences were observed between each region. This could be due to different varieties, soil, climate and grapevine management (row spacing, pruning…). Models were also founded to predict nitrogen content of leaves using the biophysical parameter CHL (2016: R^2=0,64, 2017: R^2=0,59). These promising results still need to be confirmed with 2018 data. To improve accuracy further work will be carried out with other innovative methods such as machine learning.

Keywords: satellite remote sensing, fertilization, intra and inter-plot variability, biophysical parameters.

1. Introduction.

Are satellite images relevant to manage vineyard fertilization considering different regions and varieties?

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Introduction & Objective

Nitrogen (N) is a **key element** for plants and for grapevine in particular. Its availability and metabolism along the grapevine cycle are determinant for the vine development and its annual fruit production, as well as for the plant durability [1]. The winegrower needs to determine the leaves' N status of the vineyard which is classically achieved by performing leaves analysis or leaves measurements [2]. However, leaves sampling is very **time-consuming** and is usually done **randomly** without taking into account the **intra-field heterogeneities** which leads to non-representative values of field nitrogen status.

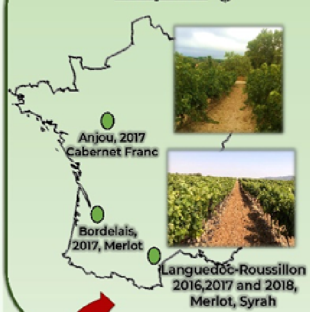
According to [3], N deficiency could lead to leaves' structure with a larger intercellular space and a less organized parenchyma. These modifications could be detected by optical sensors [4], [5], [6]. To our knowledge, only **airborne and UAV** imagery have been tested to automatically map N status of vineyards [4,5,6]. However, these solutions are **expensive** and nutrition is a cost-sensitive issue in vineyards [7]. **Satellite** imagery can provide a **larger spatial and temporal coverage** which could lead to lowering the cost and offering a **best value for money** product for winegrowers.

This study aims at evaluating the **potential of satellite multispectral imagery** (Spot 6/7 and Sentinel-2) to **help managing nitrogen fertilization** considering different (1) spatial and spectral resolutions, (2) regions, (3) vineyard varieties and (4) years of study.

Materials & Methods

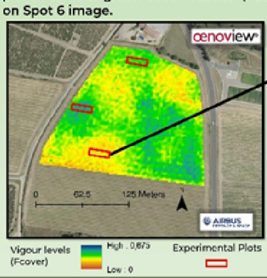
Leaves N status field measurements over vineyard plots

Study sites



Choice of experimental plots

Plot in several vigour levels have to be chosen at veraison stage (intra-field variability). This is done by choosing homogeneous plot in term of green cover fraction (Fcover [8] from Oenoview©) on Spot 6 image.



- 130 plots with a size of 5x20m
- Only 2 rows to optimize field measurements

Field observations

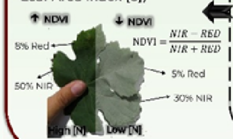
N status measured with:
- Leaves analysis
- Chlorophyll indices with a proxi-sensor (DUALEX ©)

Observations localised with a centimetric GPS

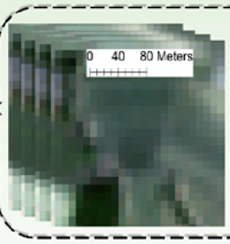
Analysis of correlations → which prediction capacity?

Satellite imagery and derived vegetation parameters or indices

Test of various vegetation parameters potentially linked to nitrogen leaves status (vegetation indices such as NDVI [9] and biophysical parameters such as Fcover or Leaf Area Index [8])



$$NDVI = \frac{NIR - RED}{NIR + RED}$$



Sentinel 2
- Spatial resolution : 10m to 60 m
- Number of spectral bands : 13
- Free access
- Systematic revisit every 5 days

Spot 6/7
- Spatial resolution : 1.5m to 6m
- Number of spectral bands : 6
- Commercial distribution
- Acquisition upon request

Preliminary Results

Significant **differences in nitrogen leaves concentration** from field measurements were observed between each region in 2016 and 2017. This could be due to different varieties, soil, climate and grapevine management.

Best correlations between biophysical parameters derived from satellite imagery and nitrogen leaves concentration were found in Bordeaux area using **multivariate models** with the leaves Chlorophyll content and LAI parameters calculated from Spot 6 (2016: r^2=0,64, 2017: r^2=0,59).

These promising preliminary results **need to be confirmed** using the 2018 and 2019 field measurements.

Other correlations have been found with potassium (K) and phosphorus (P).

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Conclusion

Work still need to be carried on with vegetation indices and Sentinel 2 images.

Although **Sentinel 2** spatial resolution (10 to 60m) is lower than those of Spot 6/7 (1.5 to 6m), according to [4], [5] and [6], spectral bands of **Sentinel 2** seems to be **more accurate** to assess vegetation development, in particular **regarding N status**.

Sentinel 2 data are **freely available** which is a major advantage to provide an operational service at an **affordable price**.

No literature has been found about the vineyard N status map with Sentinel 2.

To adapt the 2019 field protocol to the Sentinel 2 resolution, the plot size will be extended to 40x40M. Furthermore the number of plot by field will increase in order to assess the entire field variability and improve the validation of our models.

Potential of other innovative approaches (e.g. **machine learning**) are also under investigation.

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