Smart vineyard: management and decision making support for wine producers

In parallel to the development of new tools and practices in the agriculture, the world of wine is heading towards a transformation enabling precision agriculture applied to viticulture. The objective is to gain in efficiency, in productivity and overall in quality of wine. Digital technologies including IoT can bring solutions to winegrowers, helping them in the decision making process in order to adapt their production mode in their vineyards.

Key digital technologies applied for vineyard

1 State of the wine industry

Vineyard surface

The world’s vineyard surface area in 2016 was evaluated at 7.5 million acre according to OIV (International Organisation of Vine and Wine). Total surface is in decline since 2000, where the surface was assessed at 7.8 million acre mainly due to the reduction of European vineyards.

During the same period, the production of grapes has grown (+17%) and reached 76 million of tons last year. This rise is notably driven by Chinese demand and is related to an increase in yields combined with an improvement of wine-growing techniques.

Wine consumption

Globally the consumption of wine has declined over the last 10 years. While consumption is declining in traditional wine countries, especially in Southern Europe it is progressing in the New World countries. Since a couple of years, the interest in smart vineyard comes from the growing attention from customers in the quality of wines as well as in the way of producing it.

Connected solutions

Today, the concept of smart vineyard refers to new measurement tools based on the collection of a multitude of data thanks to the use of wireless sensors eventually combined with images from satellite or drones. Comparable to Predictive Agriculture, predictive Viticulture is based on the observation and measurement of environmental data to optimise crop production and minimise environmental impact.

Wireless sensor network

Water-based indicators

The level of water in the vine is the main measure to monitor as water is one of the most critical element to indicate the vigorous status of the wine. Typically, when the vine lacks water, it restricts crop development, which can stop the maturation of the grapes. In case of harvest time, picking must be done as quickly as possible to avoid acidity to fall or to alter the taste of the juice.

Agronomical indicators

Actually, wine growers take into account multiple types of factor regarding the plant itself but also the soil and the weather in order determine the length and frequency of irrigation events.

Other agronomical parameters can be also into consideration such as evapotranspiration.

Daily evapotranspiration provides the quantity of water removing from the soil and informs the wine growers on the amount of water to apply to a vineyard block. Climatic measurements are in addition a key factor driving phenology, yield, quality and timing of operations.

Some other sensors can also be used to collect other type of data as follows:

- Leaf hydration;
- Air and soil moisture;
- Vine environment factors: air and soil temperature, sun power, atmospheric pressure, PH, rainfall, anemometer, UV and solar radiation.
As regards to soil moisture, the data can help winegrowers to understand how water moves in soil and the areas where roots are most actively taking up water by monitoring different levels in the soil. Thus, moisture sensors can provide the data regarding the effect of irrigation or rainfall on potential leaching.

It is worth noting that irrigation is a common practice in the New World wine like USA or Australia while in Old World wine like France or Italy, the natural rainfall is considered as the main source of water keeping terroir characteristics.

Satellite and drones imagery

Sensors can be combined with the usage of imagery for further accuracy thanks to the use of satellite or drone. Typically, vine vigor maps or soil maps could help to determine the best representative location within a block or a vineyard to implement sensors. It could be used in real time to visualise differences in vine vigor or to detect the dose of fungicide necessary to fight wine disease.

Astrium Infoterra (a EADS subsidiary) and the Institut Coopératif du Vin (ICV) have jointly developed Oenoview, a tool providing these maps thanks to satellite images based on natural radiation emitted by the leaves of the vine and via an infrared technology mapping the planes. In Bordeaux, Chateau Pape Clément has acquired its first drone in 2014.

There is also ongoing research led by European scientists and testing the use of robots equipped with sensors and camera. The project developed a prototype robot called Vinbot. The objective is to reduce error margin from 30% (manually) to 10-15% with robots. The robot is expected to be commercialised in 2-4 years.

Vineyard management software

The collection of data from sensors creates new opportunities for innovation in the vineyard in the field of prediction systems. But the key transformation in Predictive Viticulture resides in the ability to couple those collecting data with data from other sources than wireless sensors and mappings such as historical/knowledge data including vineyard characteristics, grape varieties specifications or previous vintage results and cartography.

Once those several data gathered and combined, they are processed and analysed in order to provide workable data for winegrowers through visual dashboard or recommendations. In case of disease treatment, the winegrower get access to a dashboard displaying the tracking, and the areas for fungicide dosing.

Figure 3: Vineyard management software

Providers

Predictive Viticulture started a couple of decades ago in wine’s new world regions like Australia or Chile. Emerging IoT technologies have globally enlarged the interest around 2009 with the development of sensors dedicated to vineyards. There are many solutions developed by researchers or start-ups. Most of them provide a kit encompassing sensors along with processing software with dashboard as listed in the table below. They work mainly with large vineyards which are essentially trials or small deployments in different wine regions including US, France, Germany, Switzerland, Portugal, Spain and Italy.

Industry players such as Verizon, Intel, Ericsson, Libelium consider the application of IoT in vineyards as critical for the future and participate to trial or small deployments.

<table>
<thead>
<tr>
<th>Solutions</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>SmartVineyard</td>
<td>Soil monitoring system</td>
</tr>
<tr>
<td>Aquaflex</td>
<td>Soil monitoring system</td>
</tr>
<tr>
<td>VineMetrics</td>
<td>Water status, cluster weight, shoot growth monitoring</td>
</tr>
<tr>
<td>PreDivine</td>
<td>Vine disease prediction</td>
</tr>
<tr>
<td>MECS-VINE</td>
<td>Canopy measurement</td>
</tr>
<tr>
<td>Picore/Irstea</td>
<td>Pesticide use</td>
</tr>
<tr>
<td>ITK</td>
<td>Vine stress</td>
</tr>
<tr>
<td>Fruition sciences</td>
<td>Fruit maturity</td>
</tr>
<tr>
<td>eVineyard</td>
<td>Vine management software</td>
</tr>
</tbody>
</table>
Opportunities for wine producers

All along the value chain in the vineyard, the use of digital technologies can be applied for a better monitoring and comprehension of wine production. The wine producers have new tools to control the status of their vines in order to better anticipate the actions to take on their vineyard.

Predicting vineyard conditions

The main opportunity for winegrowers is to assess vineyard conditions in order to define the optimal time and location as well as the ideal amount of water, fertiliser or fungicides to apply on vine. As already mentioned, controlling vine water across the season is essential for wine quality, as it specifically defines yield, color and aroma.

Waterstress

The management of the hydration status is called water stress. Water stress can be monitored daily and can provide irrigation requirements for a week-period. Detecting the accurate ripeness of the grapes gives the optimal time for harvesting. Predicting the optimum time for harvesting can significantly improve quality and minimise risks for the grapes. Consequently, the yield of the wine is increased. Collecting soil is also key for nutritional analysis.

Globally, analysis can help wine growers to optimise crop load and vine balance by better anticipating different operations including pruning, green operations, soil, cluster work, fertilisation and harvest preparation.

Preventing disease

Devastating diseases and pests (typically, mildew, oidium, botrytis, esca) affect wine grape production and cause every year enormous economic damages. The diseases are very destructive for winemakers as they attack the long-lasting organs of vines, causing inevitably their death.

The impact of the diseases can be measured in all major wine regions. In France, 13% of wine production was lost in 2015 resulting in a loss of EUR 1 billion. In California, annual yield losses account for 14% of the producer gross value of wine grapes.

Most of traditional treatments are inefficient because they are not administered at the right time. The interest of digital technologies here is to forecast disease development thanks to the ability to calculate local grape disease intensity from the data captured by the on-site sensors.

Managing crop

In order to improve the viticulture, the use of collected data will directly improve the production practices, the crops and the tools:

- Global and specific remote view on crop, especially in steep vineyard;
- Understanding vineyard variability, control of aspects of terroir with precision;
- Identify areas with distinct climatic conditions for a unique wine;
- Improved risk assessment by zone;
- Improved temperature control practices;
- Enhanced pre-planting decisions;
- Improved management practices based on fruit response.

Better vineyard management

A key opportunity for winemakers is also to get access to real-time data of their vineyards anytime and anywhere, allowing to properly prepare all the operations and helping in taking actions. As a result, the grower can save labour time thanks to improved organisation:

- Prediction of dates of events to enable and organise activities;
- Anticipation of early or late ripening areas to fine tune harvest decisions;
- Identification of bad outcomes coming from climate or practices;
- Sizing the crew for picking;
- Tank allocation planning;
- Estimation of yield loss before harvest;
- Automatic reports for compliance or for subvention.

Impact of the transformation

Financial impact

The use of new technologies promises to lower production costs between 20 and 30% which would be highly significant for winemakers.5 Cost reduction is mainly coming form optimising the utilisation of water, fertilizers, fungicides and also from working efficiently in the vineyard.

Though, the main drawback for wine growers is the capability to invest and to modernise their practices of production. They often face a tight economic situation with very limited investment abilities in new production tools and limited access to credit. For instance, the costs of wireless sensor system start from around EUR 2000, a drone costs between EUR 1000 and EUR 3000 per month (according to surface) and robots will be commercialised at EUR 30000.

A difficult adoption

From the winemakers’ perspective, despite the promises of Predictive Viticulture in terms of reliability and costs savings, relying on their instinct to manage the vineyards remains key. Indeed, the willingness towards the use of technologies in vineyards is split between the recognition of required innovation in the field and conventional methods.

In addition, winegrowers are not reputed to be tech savvy. Today, winegrowers mainly use digital tools for commercial and marketing activities. Only few winemakers use digital for their cellar and wine. According to a barometer about connected winemakers in a French wine region6, 24% of survey respondents recognise the benefits of innovation in viticulture and 1/3 know about digital tools for soil maintenance, processing and vinification but do not use them.

Indeed, despite the success of few implementations of technologies in wine world, it is necessary for winegrowers to concretely identify what they want to achieve with new technologies before any larger adoption.

Sustainable viti-viniculture

Predictive viticulture has also a non-negligible impact on environment. For example, the ability to predict an optimal use of resources enables the wine growers to minimise impact on the environment by growing grapes more naturally and in a healthier way.

With regards to water consumption, in the California region between 1,1 and 1.9 million liters of water are used per acre vineyard.8 The use of sensors, such as those offered by Fruition Science, promises a reduction of water quantity up to 60% of water per year.

60 liters of water required for 1 glass of wine in California

Also, using fungicide against diseases at the right point in time thanks to monitoring and prediction will enable the reduction of its use from 15% up to 30% according to Iristea.

The results from early implementations have been somewhat mixed explaining partly the reluctance of winegrowers to use digital technologies. Typically, Chateau Lagrange in Bordeaux region has trialed sensors and drones and has considered the solutions commercially premature7 with results being not reliable compared to conventional techniques and field observations. Nevertheless, new technologies are seen as complimentary information to traditional methods.

77% of winemakers are doubtful or not convinced about spending time and money in digital

References

5 https://www.vineyardapp.com/blog/2015/09/16/use-of-technology-in-the-vineyard/
6 1er baromètre du vigneron connecté - 2017 - La Vigne Numérique
8 http://www.colorado.edu/geography/class_homepages/geog_4501_sum14/Presentations/StExample-NCa%20Pr11.pdf
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