Pas à pas pour une adaptation des pratiques en faveur de la transition écologique en viticulture

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Summary

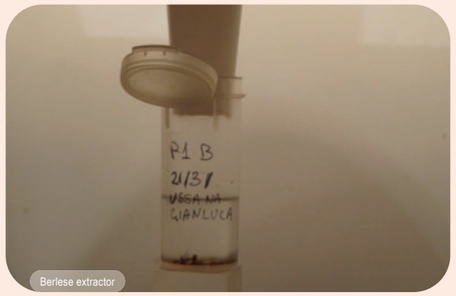
1.1 Soil biodiversity

The soil is a complex system inhabited by numerous individuals: from the simplest bacteria to annelids such as earthworms, or plants with roots tens of centimeters long: many of them are capable of positively influencing wine production. However, some traditional cultivation practices, especially if carried out incorrectly, can lead to a reduction, even drastic, in their consistency with a consequently loss of a series of ecosystem services provided by them that lead to the reduction in quality and/or quantity of wine production.
Therefore, research, experimentation and soil management activities become fundamental to be able to derive maximum benefits from all the organisms present in it.

Objectives:

Measuring the presence and consistency of living organisms present in a given system, in this case the viticultural soil, is a way to know its state of health so as to be able to apply the best conservation or improvement strategies.
Greater attention towards the soil resource can also be useful for the promotion of a territory and its products, highlighting the contribution made by the winemaker in the preservation of the landscape and in the use of more environmentally friendly practices.

Echantillon de sol



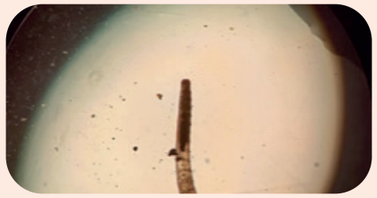
Berlese extractor

Applications:

First of all, it is important to correctly measure the biodiversity present in each soil through adequate indices: among the over 500 presented, one of the most successful is the QBS-AR which works by applying a score to each class of arthropods present in the soil in function of their presence and degree of adaptation to edaphic life. From some research it has been established that a higher QBS-AR score corresponds to better organoleptic characteristics of a wine.
Various practices favor the life of soil organisms:

- manure, especially if free from antibiotics, is the best form of nourishment for many organisms; a similar effect is also obtained by the company-produced compost produced from pruning waste; to prefer grassing to soil tillage which inevitably modify various characteristics of the soil (e.g. structure, provision of nutritional elements) and consequently the life within it;
- the repeated passage over the same portions of land, especially if carried out by large machinery, favors compaction and asphyxiation, thus reducing the development of aerobic microorganisms: there are a lot of measures linked to the machine/tractor, its control and propulsion organs or working techniques (such as working on alternate rows) which allow the negative effects to be reduced.
- the distribution of products based on mycorrhizae or bacteria contributes positively to the sustainable management of the vineyard.


Micro- and mesofauna obtained from the samples



Results:

The benefits obtained are many, among which the following must certainly be remembered:

- **Nitrogen fixation** is certainly one of the most famous ecosystem services; it is carried out by different species of bacteria in symbiosis with different plant species (including various legumes) and allows an average of 100-120 kg/hectare/year of nitrogen to be added to the soil, thus saving money on the purchase and distribution of fertilizer.
- **The nitrification process** (transformation of ammoniacal nitrogen into the form most absorbed by plants - the nitric one) is also carried out by aerobic bacteria naturally present in the soil: in this case it will therefore be important to avoid the formation of water stagnation.
- **Different bacterial species allow the chelation of iron,** thus making it available for the plant, while others allow the mobilization of elements such as calcium, zinc, magnesium and manganese: this improves the efficiency in the use of fertilizers, as microelement deficiencies sometimes occur due not so much to the poor supply of the soil, but rather to the difficulty of
absorption by the roots.
- **A series of bacteria have been found in the soil** - the so-called growth promoters (PGPR) which, by stimulating the growth of secondary roots and therefore the volume of soil explored by them, favor a more balanced development of the plant and sometimes better productive performances.
- **Mycorrhizae** (symbiotic associations between some fungal species and plants) also improve the nutritional status of the vineyard as the hyphae transfer water and elements absorbed by them to the plant in exchange for photosynthesis products: in this case attention must be paid to fungicide treatments as any residues, ending up on the ground, can inhibit the development of some species implicated in this association.
- **Some studies report an increased tolerance to water stress** thanks to the action of some microorganisms with endophytic activity capable of positively influencing the water content of the plant and its balance with the outside world.
- **Biocontrol agents (BCA) instead, promote greater resistance to diseases** (especially bait disease) as they occupy the same ecological niche as some fungal agents, taking away their nourishment.
- **Microorganisms can contribute to the development of the terroir,** better characterizing local productions and promoting greater commercial visibility.

More informations:

1. Manual on biodiversity management published by the Prosecco Consortium.
https://www.prosecco.it/wp-content/uploads/2021/01/MANUALE_alta-risoluzione.pdf

2.Summary of a seminar on good practices for biodiversity in the vineyard.
https://www.isprambiente.gov.it/files2020/notizie/Resoconto_Workshop_vigneti_Boca_16_1_2020.pdf

3.Introduction to the biodiversity of viticultural soils and methods for its evaluation with the results of some research.
http://www.viten.net/files/9fe/9fe443ca1a5a3dbc6ebfac0984e12d01.pdf

4.Comparison between the biodiversity of the soil present in some vineyards cultivated with different production regulations.
https://www.researchgate.net/publication/344887171_La_biodiversita_del_suolo_in_vigneti_Valpolicella_convenzionali_RRR_Riduci_Risparmia_Rispetta_o_biologici

5.Description of the main activities useful for increasing the presence of microorganisms in the soil.
Broggio - Buone pratiche per aumentare i microrganismi nel terreno - Vite&Vino n.1/2023.

6.Description of a method useful for measuring and evaluating soil biodiversity.
Zanzotti, Ippolito, Mescalchin - Come valutare in vigneto la qualità biologica del suolo - Vite&Vino- Informatore agrario n. 27/2017.

7.Analysis of a methodology useful for monitoring soil biodiversity.
Giannone, Tonina, Zanettin, Marini - Un esempio di monitoraggio della biodiversità del suolo - Vite&Vino n. 1/2021.

1.2 Useness of covercrop for Soils and biodiversity


Winter cover crop in Sardinia


Cover crop in Trentino region

In the last 50 years, as a result of a greater attention to certain issues, such as the development of a sustainable agriculture which is more respectful of environmental balances, the decrease in the costs of production, especially due to mechanization, and the increase in grapes quality, there has been a greater focus on alternative methods to traditional tillage.
This is where the grassing of modern vineyards comes in, one of the best soil management techniques, thanks to the undoubted advantages it provides.

Objectives:

Correct grassland management, which must always be modulated according to the soil and climate characteristics of the site, makes it possible to achieve important objectives:

- Improving important soil characteristics;
- Improving the workability of the vineyard at certain times of the year;
- Decreasing the environmental impact;
- Improving the condition of the vines;
- Improving the quality characteristics of the wines;
- Reducing vineyard management costs.

Applications:

This technique basically consists in controlling the grass grown in the vineyard through a series of mowings, the number of which varies depending on the climatic conditions of the site, in different times during the growing season.

There are different types of grassing, so that it can be adapted to different types of soil and climate environments:

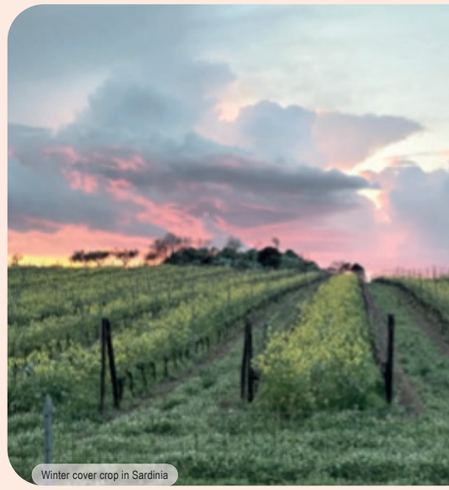
1) permanent: the turf covers the ground throughout the year;
temporary: the turf only covers the ground during a specific period of the year (usually from autumn to spring), and is then broken up by tilling or left to dry out (this is the solution for areas, such as the Mediterranean, characterized by low rainfall in spring and summer and with the only possibility of emergency irrigation);

2) total: it affects the entire surface;
partial: it involves only a portion of the surface (e.g. the inter-row or alternating inter-rows);

3) natural: consisting of spontaneous species.
artificial: consisting of suitable mixtures specifically designed to provide certain advantages such as less competition for the vine. Many of the species utilized, belong to the leguminous families (they allow nitrogen-fixing, but must be reseeded every 2-3 years) or grasses (species that are usually more competitive than the previous ones, they lead to a reduction in bunch weight and therefore in production, but to an increase in sugar content).


Cover crop: sowing

Results:


Winter cover crop in Sardinia

- **The supply of organic substance due to the decomposition of cover crop biomass improves the structure of the soil** and contributes to increase the number and complexity of edaphic organisms. Furthermore, reducing the effects of erosive phenomena in sloping vineyards is fundamental, thanks to the «dampening» effect which helps to preserve the surface layers of the soil, well known as the richest in organic substance and nutrients.The grass covering acts both with their biomass, decreasing the kinetic energy of rain and surface water during runoff, and with their roots, retaining portions of soil.
- **In the case of cover crops made up of a good presence of legumes, nitrogen fixation** by some bacterial species of up to 100-120 kg/hectare/year is observed, thus allowing a reduction in costs for the purchase and distribution of fertilizer.
- **The presence of cover crops, apart from reducing compaction of the soil due to the machinery wheels, favors the improvement in the accessibility and bearing capacity of the vineyard soil** with the advantage of being able to carry out the main crops activities more promptly;
- **The root system of cover crops allows, especially in the winter period characterized by a substantial dormancy of the vine, the reduction of nitric nitrogen** and of any pesticides released into the groundwater by the phenomenon of leaching, thus decreasing the risk of environmental pollution. The roots themselves, once decomposed, will release their main constituents, including slightly mobile nutritional elements such as phosphorus and potassium which had also been absorbed from the surface levels of the soil, thus favoring their mobilization.
- **As far as the plant is concerned,** there is a better adaptability of the shoots and control of vigor, useful in the case of vigorous vines or rootstocks grown in fertile soils. Furthermore, the leaf mass decreases: the extent of botrytis attacks decreases and consequently the number of phytosanitary treatments close to the harvest time.
- **Some qualitative characteristics of the must improve:** there is an increase in the sugar content, in anthocyanins and total polyphenols of the must.
- **A correct management of grass cover allows for a reduction in costs,** compared to traditional processes carried out with a rotary tiller or cultivator harrow, thanks to a reduction in working times (movement speed is faster) and fuel consumption. The savings due to nitrogen fixation should also be taken into account.

Together with the numerous advantages, it is also important to point out which may be the negative effects of this technique, mainly detected in environments characterized by a lack of spring-summer rainfall:

- **Competition for nitrogen increases**, with negative repercussions on the content of readily assimilable nitrogen-APA present in the must;
- **Competition for water increases** along with the development of water stress and, as a consequence, a less development of the vine; this problem is especially important in young vineyards, characterized by a less development of the root system: a valid solution in these cases is to carry out grass covering a few years after planting the vineyard.
- **Some articles report about a decreasing in the titratable acidity of musts**, although a study conducted in Sardinia did not reveal a significant influence of grass cover on this parameter.
- **Contributing to the cooling of the soil, lands with vegetal cover favors damages from frost**: it is advisable to shred it before the vegetative awakening of the vine.

More informations:

1.Chapter of a book that deals in depth with cover crops.
https://www.venetoagricoltura.org/upload/pubblicazioni/GUIDA_PER_IL_VITICOLTORE/056_inerbimento_vigneto.pdf

2.Comparison between different soil management techniques on Vermentino in Sardinia.
https://www.soihs.it/public/43/3%20Piras_etal.pdf

3.Document on cover crops and conservative soil management in the Cannonau area of Jerzu.
https://www.sardegnaagricoltura.it/documenti/14_43_20161104125841.pdf

4.A webinar with guest Prof. Luca Mercenaro who talks about cover crops.
https://www.youtube.com/watch?v=5ZBaj-xER_Q&pp=ygUPYmlnb3QgbWVyY2VuYXJv

5.Presentation on a study carried out by the Agris Sardegna agency on the alternative management of viticultural soil.
https://www.sardegnaagricoltura.it/documenti/14_43_20161104130306.pdf

1.3 Importance of vineyard soils fertilization

Since the beginning of modern agriculture, fertilization has been performed applying, mainly, chemical nutrients to the plants. But, during last ten years a new paradigm has been developed for having more resilience and healthier crops. It is more important to fertilize soils, consequently, plants will be more productive and healthier. But soil is a non-renewable source for human beings. The European Commission have realized of the importance of this element and they have created an important plan for recover soil health.
https://environment.ec.europa.eu/topics/soil-and-land/soil-health_en

Objectives:

Remark the importance of soil as a source of live. Be aware of excessive nutrients present in soils and try to perform an accurate and rational program of fertilization. Mention the importance of microorganisms as a key part of nutrient cycle. Mention the importance of organic matter as an important element to have fertilized soils.

Applications:

1 - The use of European databases for evaluating soil health.

2 - Evaluation of physicochemical parameters of soil and plants.

3 - Evaluation of microorganisms present in soil (Biological analysis).

4 - Farming management, application of organic matter and microorganisms for increase fertility of soils and improve wine taste.

Results:

1 - There is a remarkable excessive concentration of many important nutrients (specially Nitrogen and Phosphorus) due to many years of chemical fertilizers without control and we have concerned about this problem. Now we are trying to solve this issue through European policies.

> References:
> https://vb.nweurope.eu/media/15027/phos4you_201_schilthuis_eu_com.pdf
> http://www. nine-esf.org/files/ena_doc/ENA_pdfs/ENA_c21.pdf

And, the use of this database will improve a better knowledge of our soils.

> Reference:
> https://esdac.jrc.ec.europa.eu/resource-type/european-soil-database-soil-properties

2 - So that, it is important to bear in mind a solid reference for a rational fertilization.

> Reference of levels of nutrients in soil and leaves of vine plants during a vegetative cycle:
> https://pubs.extension.wsu.edu/vineyard-nutrient-management-in-washington-state-replaces-pnw622-publication

3 - Biological analysis should be implanted in farming. An example of its importance can be obtained as a decision tool for implanting vineyards or improving wine fermentation.

> References:
> https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2017.00821/full
> https://journals.asm.org/doi/10.1128/mbio.02527-14

4 - Also, a good implementation of management it is a key factor. So, it is important to have in mind, practice management.

> Reference:
> Good management of nutrients in soil affects productivity:
> https://ejpsoil.eu/sustainable-soil-management-agricultural-production.

Also, organic matter is a key factor for having a healthier soil.

> Reference:
> Type of management affects the vineyard:
> https://www.frontiersin.org/articles/10.3389/fmicb.2023.1242267/full.

And finally, the use of microorganisms as an important partner in fertilizations programs will improve our performance because it affects wine taste.

> Reference:
> microorganisms and wine.
> https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6880775/.
> Microorganisms and fertilization in soil vineyard:
> https://ui.adsabs.harvard.edu/abs/2019AgEE..272..114P/abstract

More informations:

Program of fertilization:
https://www.uco.es/fitotecnia/fertilicalc.html

Eurpean Project about soil health:
https://ejpsoil.eu/

Washington State University, more information about soil sampling and nutrient management:
https://wine.wsu.edu/extension/nutrition-and-soils/

Climate change adaptation:
https://ejpsoil.eu/climate-change-adaptation

Importance of soil against climate change in viticulture:
https://www.forbes.com/sites/johnmariani/2022/01/02/the-fight-against-climate-change-in-the-vineyard-begins-beneath-the-soil/?sh=6c9a5e143906

Importance of adding organic matter in agriculture as a tool for increasing yields:
https://www.mdpi.com/2077-0472/11/8/700

European projects of soil management:
https://ejpsoil.eu/soil-research/climasoma
https://ejpsoil.eu/soil-research/eom4soil/into-dialogue/soilx
https://ejpsoil.eu/soil-research/eom4soil/into-dialogue/artemis

1.4 Grapevine irrigation

The total water consumption of grapevines varies from 300 to 700 mm, a range that is generally higher than the annual average precipitation in many viticultural areas, as is the case of Mediterranean regions. However, grapevine is well adapted to drought-prone areas where irrigation was introduced to increase the low land yield and is, nowadays, a powerful tool to face the negative impacts of climate change.

Objectives:

Outline some of the most important concepts and features of the irrigation of grapevines.

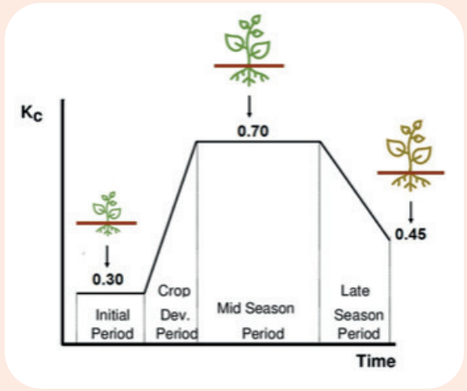
Applications:

Irrigation requirements

Crop water requirements are defined as the amount of water needed to meet the water lost through evapotranspiration by a disease-free crop, growing in large fields under no limitations regarding soil conditions, including soil water and fertility, and achieving full production potential under the given growing environment. This water loss is defined as crop evapotranspiration (ETc) under standard conditions, that can be obtained by the product of the reference evapotranspiration (ET0) by the specific crop coefficient (Kc). The ET0 is the reference evapotranspiration of a grass-like reference crop, and Kc is the crop coefficient. In fact, ET0 represents an index of climatic demand and Kc represents the influence of the specific crop characteristics. For grapevines growing under standard climatic and agronomic conditions, the Kc values recommended by FAO are: 0.30, in the initial phase, 0.70 in the mid-season phase, and 0.45 in the end of the late season phase of the development cycle (Figure 1).

Fig. 1. Crop coefficients for grapevines under standard climatic and agronomic conditions (adapted from Allen et al. 1998)

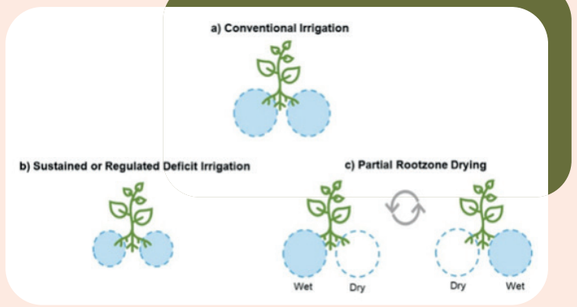
Irrigation strategies



The amount of water that is required to be applied by irrigation to a crop to fully satisfy its specific crop water requirement, whenever rainfall, soil water storage and groundwater contributions are insufficient, is named irrigation water requirements (IWR). That is, IWR will be equal to the difference between ETc and the precipitation, for a given period of time. However, grapevine is a traditionally non-irrigated crop, well adapted to drought-prone areas where irrigation was introduced to increase the low land yield but is mostly managed following schedules optimized to improve water use efficiency, like supplemental or deficit irrigation.

Deficit irrigation consists in supplying irrigation volumes lower than the irrigation crop requirements under non-limiting growing conditions, that is, below the potential crop evapotranspiration. These strategies allow for water savings in regions with present or future limited water resources. Three deficit Irrigation strategies can be considered: sustained (or continuous) deficit irrigation (SDI), regulated deficit irrigation (RDI), and partial root-zone drying (PRD) (Figure 2).

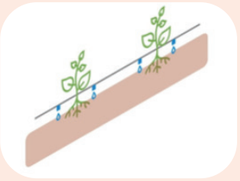
Fig. 2. Conventional and deficit Irrigation strategies.



In SDI, irrigation water used at any moment during the season is below the crop evapotranspiration demand, based on the idea of rationing the water deficit uniformly over the whole growing season. The RDI strategy consists in reducing or withholding irrigation water during specific periods to manipulate plants' vegetative and reproductive growth. The less sensitive period for grapevines to water deficit is normally around veraison when it is possible to reduce or interrupt irrigation without a significant yield reduction or decreased grape quality. The PRD technique requires that on each irrigation, alternately half of the root system is maintained in a drying state while the remainder of the root system is irrigated. This strategy allows for maintaining the upper part of vines in favorable water conditions, while the drought in part of the roots emits chemical signals that induce reduction of evapotranspiration and shoot growth.

Irrigation method: The most efficient irrigation method is drip irrigation, which is a type of micro-irrigation system that saves water by allowing water to drip slowly to the plants. The aim is to place water directly into the root zone and minimize evaporation. Drip irrigation systems distribute water through a network of valves, pipes, tubing, and emitters, called drippers (Figure 3).

Fig. 3. Schematic representation of drip irrigation



One of the important aspects of irrigation is understanding how the irrigation system applies water to crops. Whatever the type of irrigation system, it must guarantee good uniformity of water distribution, so that all plants receive the same amount of water and fertilizer, if fertilizer is applied during irrigation. To obtain high levels of performance from the irrigation system, it is important to ensure proper maintenance of its components and carry out periodic audits of its performance.

Plant water status and soil water measurements: Currently, there is a wide range of monitoring systems available to the viticulturist, based on the use of plant water status or soil moisture sensors and associated with new communication technologies that allow quick access to real-time information in platforms that integrate sensor information in a "user-friendly" way (Figure 4). These platforms also make it possible to include other decision-support parameters for irrigation management, such as meteorological information or vegetation indicators obtained by remote sensing. The integration of this information allows for the efficient use of water, minimizing the potential negative impacts of irrigation and contributing to the sustainable use of water resources.

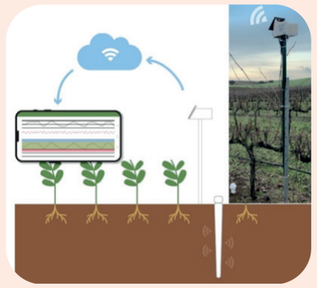


Fig. 4. Soil moisture content monitoring systems associated with new technologies (adapted from Tomaz et al., 2022).

The use of innovative technologies, such as remote sensing tools, in irrigation is a growing area, called smart irrigation. These technologies allow maps to be obtained with indicators of the state (nutritional, water, phytosanitary, etc.) of the vegetation and this information can be integrated with in situ measurements to support irrigation management.

More informations:

Crop evapotranspiration - Guidelines for computing crop water requirements,Irrigation and Drainage (paper)
https://www.fao.org/3/X0490E/x0490e00.htm

Physiological tools for irrigation scheduling in grapevine (Vitis vinifera L.): An open gate to improve water-use efficiency? (paper)
https://doi.org/10.1016/j.agee.2004.10.005

Medrano, H., Tomás, M., Martorell, S., Escalona, J.-M., Pou, A., Fuentes, S., Flexas, J., Bota, J., 2015. Improving water use efficiency of vineyards in semi-arid regions. A review. (paper)
https://doi.org/10.1007/s13593-014-0280-z

Manual de Boas Práticas Para a Gestão Sustentável de Fatores de Produção. (paper. https://repositorio.ipbeja.pt/bitstream/20.500.12207/5577/3/GO_FitoFarmGest_ManualBoasPraticas_PDFA.pdf

Yield and quality responses of 'Aragonez' grapevines under deficit irrigation and different soil management practices in a Mediterranean climate. (paper)
https://doi.org/10.1051/ctv/20153001009

1.5 Overview of agronomical options to save water in the vineyard

Among the environmental problems associated with viticulture, water scarcity is a critical issue. Climate change has a significant effect on temperature and precipitation trends throughout the grapevine growing cycle, leading to severe water deficits, therefore, affecting physiology, yield, and fruit composition.

Objectives:

Given the predicted future warming and dryness of climatic conditions in the Southern European winemaking regions, there is an increasing demand for knowledge about the possible agronomic approaches to adapt to these stressful conditions.

Applications:

Which practices may be adopted to save water and face climate change in the vineyard?
Various options such as deficit irrigation, the use of cover crops, water reuse, selection of varieties and rootstocks resistant to drought and heat stress, or soil and plant monitoring, can be applied to adapt to water scarcity conditions while ensuring sustainable yields and grape quality.
Grapevine irrigation can be managed following strategies to improve water use efficiency, known as deficit Irrigation strategies,
Cover crops are spontaneous vegetation or sown plant species associated with a perennial crop, planted in the interrow (Figure 1). The use of cover crops in the interrow of vineyards is a well-known practice to promote reductions in vine vigor and improve berry composition but cover crops also provide several other agri-environmental benefits: improved soil protection that contributes to reducing soil erosion and increasing soil water storage; climate change mitigation since they can contribute to carbon sequestration by increasing soil organic matter content and soil health at the same time; increased biodiversity with a positive effect on providing habitats for natural enemies of grapevine pests, thus reducing pesticide requirements (Figure 2).

Fig. 1. Cover crop in the interrow of a vineyard in Alentejo (Southern Portugal)

Water reuse can be a viable solution for Mediterranean agriculture. It helps in reducing the need for new water resources and acts as an adaptive measure to tackle the effects of climate change. Additionally, it also enhances the availability of water resources, minimizes wastewater outflow, and has the added advantage of valuing the social and environmental significance of water with additional environmental benefits.

Fig. 2. Benefits of cover crops

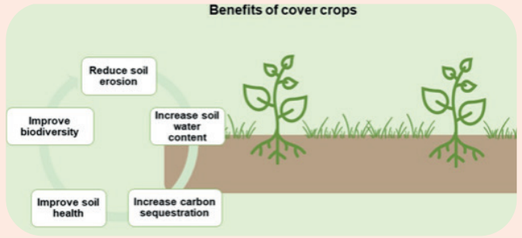


Fig. 3. Biochar and straw mulch in a vineyard in Alentejo (Portugal).

Precision viticulture involves using technologies in which soil and plant sensors, drones, satellite images, robotization, and automation can help decrease costs and improve input use efficiency such as water or fertilizers. Precision viticulture is based on technologies that can detect spatial heterogeneity of vineyards and that will determine inter-annual and intra-vineyard variability, ensuring that the right amount of input is applied at the right location in the vineyard (Figure 4).

The combination of variety/rootstock for a certain environment may contribute to drought and heat tolerance. Rootstocks influence vigor and drought tolerance via, for example, differences in root growth and capacity to extract water.
Nature-based measures, such as mulching with crop and forest residues or with C-rich products like biochar could be effective in reducing soil erosion, increasing soil organic matter, and thus improving soil quality and the capacity of soils to store water (Figure 3, Video).

Fig. 4. Precision viticulture tools

More informations:

Modern viticulture in southern Europe: Vulnerabilities and strategies for adaptation to water scarcity. (paper)
https://doi.org/10.1016/j.agwat.2015.08.021

Vineyard mulching as a climate change adaptation measure: Future simulations for Alentejo, Portugal. (paper)
https://doi.org/10.1016/j.agsy.2018.04.006

Regulated deficit irrigation and partial rootzone drying as irrigation management techniques for grapevines. Deficit Irrigation Practices 22,.
https://www.fao.org/3/Y3655E/y3655e11.htm

Evaluating Strategies for Adaptation to Climate Change in Grapevine Production–A Systematic Review. (paper) . https://doi.org/10.3389/fpls.2020.607859

Can straw-biochar mulching mitigate erosion of wildfire-degraded soils under extreme rainfall? (paper)
https://doi.org/10.1016/j.scitotenv.2020.143219

Influence of cover cropping on water uptake dynamics in an irrigated Mediterranean vineyard. (paper)
https://doi.org/10.1002/ird.2115

Effects of cover crops and irrigation on 'Tempranillo' grapevine and berry physiology: an experiment under the Mediterranean conditions of Southern Portugal. (paper)
https://doi.org/10.20870/oeno-one.2021.55.3.4629

Video: The caption of the video must be the following: An experiment in a vineyard in Alentejo with the application of biochar and straw mulch
(Project SOLVIT - Solutions to restore degraded soils in Mediterranean vineyards via organic mulch and biochar derived from Viticulture industry waste; contact: Dr. Sergio Prats, sergio.prats@uevora.pt)

1.6 Vitiforestry

Agroforestry is the association of trees and crops on the same agricultural plot, on the edge or in the open field. In viticulture, this practice presents innovative characteristics that meet the principles of agro-ecology

Objectives:

Mediterranean agriculture has been practicing agroforestry for thousands of years. From this heritage and practices dating from the Middle Ages in France, new forms of agroforestry specialized for viticulture have emerged over the last twenty years.
These new forms of contemporary viticultural agroforestry present innovative characteristics which respond to the principles of agro-ecology and present interests from a societal point of view (minimal impact on natural resources), from a environmental (protection of biodiversity) and from an economic point of view.
Agroforestry is fully part of an approach to ecological intensification of agricultural practices.

Inter-rows vitiforestry example in Bolivia in association with vegetables cover crops (potatoes)

© Stéphane Badet

Applications:

Viti-forestry is the association of trees and vines on the same agricultural plot, on the edge or in the plot, outside the rows or in the rows of vines. In viticulture, this practice presents innovative characteristics that meet the principles of agro-ecology.
Contemporary viticultural agroforestry seeks to adapt to the constraints of modern viticulture, in particular to the size of equipment for the maintenance and protection of vegetation or for the implementation of mechanized harvesting.
There are currently different types of development: rows of trees interspersed between rows of vines, shrub hedges at the edge of the plot or interspersed between islands of vines, isolated trees planted within the row of vines.
Various species of trees or shrubs can be chosen depending on the objective of the operator. For an agricultural plot to be considered vitiforestry, it must contain fewer than 100 trees per hectare. In order to avoid Vine-Tree competitions, it is advisable to limit yourself to a density of between 30 and 40 trees per hectare. In this type of configuration, there are no competitions highlighted over the first 10 years of co-planting (Vitiforest project).

Finally, there is also the possibility of diversifying the layout of the plots, in particular the spacing between the lines of trees and the distance to the rows of vines.

Results:

The advantages put forward to justify this practice are numerous and concern numerous potential “services”.
Growing trees in combination with vines has the effect of combating erosion, preserving soil moisture, recycling nutrients while reducing the impact of viticulture on the environment (the tree is by example a CO2 trap), effects on soil structure, etc.
The impact of vitiforestry on biodiversity is still poorly documented. However, it is possible to say that it provides botanical diversity and an additional layer of vegetation creating new ecological niches.

The Vitiforest project also showed that the introduction of the tree does not have strong and homogeneous effects on the distribution of pests (green leafhoppers) and arthropods. However, it has an impact on the abundance of earthworms, due to the presence of grass, and on the abundance of certain microbial taxa.
By creating new strata of vegetation and new ecological niches, viti-forestry contributes to improving aerial or soil biodiversity.
By modifying air circulation, the water cycle or creating shade, the establishment of trees within a vineyard plot will also have an impact on its microclimate and on temperature relationships. -humidity-wind. It is thus observed that near a tree the recycling of deep water resources towards the atmosphere occurs, leading to an increase in relative humidity and a cooling of the air. Water becomes trapped by condensation of humidity (dew) and rain is intercepted (3-5mm).

The hedges around the plots also help to limit aerial drift of phytosanitary products.
Vitiforestry can also make it possible to move away from Vine mono-culture by choosing to plant fruit trees, thus providing new agricultural production or by choosing to valorize the biomass produced by trees in the form of energy, carbon storage, lumber. These new outlets could ultimately lead to additional income.

Vitiforestry is also of interest at the societal level. It meets the growing needs of consumers to have a quality product, with minimal impact on natural resources. The image conveyed by the product consumed occupies a growing place in today’s society and consumers tend to favor respectful production systems that meet their expectations. The presence of trees and hedges in viticulture is generally well received by local residents and consumers. The introduction of trees into a vineyard can therefore contribute to a quality landscape and a positive image associated with the product sold. Finally, the hedges around the plots help to limit aerial drift of chemical products.

More informations:

Links to IFV documentation and technical sheets
https://www.vignevin.com/wp-content/uploads/2019/03/1811_ESOPE_IFV_Brochure_Agroforesterie_web100_DPI_VF-1.pdf
https://www.vignevin-occitanie.com/fiches-pratiques/agroforesterie/

Links to professional articles and documents
https://www.syndicat-cotesdurhone.com/upload/article/file/fiche2annexehaiesaura-61e698414454f.pdf
https://extranet.bivb.com/technique-et-qualite/publications-techniques/plaquettes-techniques/gallery_files/site/2992/48177/66048.pdf

Link to INRAE VITIFOREST presentation
https://hal.inrae.fr/hal-03209987/document

Link to french association française Agroforesterie web site
https://www.agroforesterie.fr/agroforesterie-et-vignes/

Link to domaine Emile Grelier web site, example of vitiforestry
https://www.domaine-emile-grelier.fr/actions-cours.php

1.7 Vitigrazing

Vitigrazing consists of grazing sheep (mainly, but there are also grazing practices with pigs or poultry) in the vineyards.
A very old practice, brought up to date, and once again practiced on many farms around the world keen to follow an agro-environmental approach.
Australian winegrowers and New Zealanders were the first to restart this practice.


© Stéphane Badet (château Dillon)

Objectives:

0 herbicide approach.
Without herbicide, it is necessary to “contain” and control the grass in the vineyard using alternative techniques.
There are several different techniques, mowing, rolling, destruction-integration into the ground. But using these techniques results in significant consumption of diesel and soil compaction.
Vitigrazing consists of having sheep “control” the grass cover of the vines, and therefore avoiding soil compaction and consumption of fossil fuels.

Applications:

This practice first requires carefully considering plot rotations, installing mobile electric fences, and finding the right balance between the number of sheep and the surface area depending on the quantity of pastureable grass present and the height of the grass. desired grass, before putting the sheep out to pasture.
The average of 50 ewes for half a hectare over 2 days looks to be a good balance. They will pick (first the best and then the worst for them) while walking a lot.
Herd monitoring and management work (watering, overnight stays, etc.)

Results:

The sheep mow and clean the ground, replacing mechanical mowing and leaving the plot as clean as possible.
They graze right up to the foot, where the machine could not have gone or with a risk of foot injury.
Sheep are generally not very selective and consume all categories of grass present.
In addition, by moving the sheep, they lightly decompact the soil on the surface. They are also respectful of the vines and the trellising, no damage is generally observed.
Their droppings fertilize the plot, and contribute to the enrichment of the soil with organic matter (natural fertilization).
Savings from one or more mechanical mowings (saving energy, fuel, labor, money, etc.)
New production on the vineyard through the possibility of valorizing milk, cheese, meat, wool…
Presence of sheep appreciated by local residents, employees, customers and considered more friendly, less noisy and less polluting than a tractor. The sheep thus become a social mediator between the winegrower and the population.
Main limitations:
It is only possible to put the sheep in the vines in winter, after the autumn leaves have fallen, until before the first buds appear.
As soon as the vine vegetation restarts, the sheep could be tempted to eat the young leaves and buds but also the grape berries. To overcome this disadvantage, the trellising of the vines should be increased, so that the sheep cannot reach the leaves of the vines.
A lot of work in monitoring, managing the herd and organizing plot rotations, so that the sheep have enough to graze, without forcing the organization of other viticultural work to be done during the winter;
Note that some winegrowers also use sheep in the summer to remove leaves from the vines, in order to better expose and aerate the bunches of grapes.

More informations:

Links to videos of grazing experiences :
https://www.youtube.com/watch?v=A_07AKmqE_s
https://www.youtube.com/watch?v=rDnFQyToiK4
https://www.youtube.com/watch?v=fHJjIZjbMNk

Links to professional articles :
https://www.syndicat-cotesdurhone.com/upload/article/file/moutons903juin20202-5edf7948a718f.pdf
https://gard.chambre-agriculture.fr/fileadmin/user_upload/Occitanie/066_Inst-Gard/Documents/4_Productions_et_techniques_doc/Elevage/guide-paturage-vignes.pdf
https://dordogne.chambre-agriculture.fr/fileadmin/user_upload/National/FAL_commun/publications/Nouvelle-Aquitaine/24_Fiche-technique_brebis_dans-les-vignes.pdf

1.8 Low alcohol yeast

In the last years, the average alcohol content of wine has increased due to climate change that resulted in increased grape sugar levels at harvest. The high alcohol content in wine usually has a negative impact on its sensory properties increasing the perception of the heat and altering the perception of wine aroma complexity, and can also affect the general health of the consumers.
Therefore, alcohol reduction is a current challenge in the winemaking industry. One of the strategies applied to reduce ethanol production, has been the use of non- Saccharomyces yeasts able to take part in a controlled manner in the fermentation, reducing the ethanol content and positively influencing the quality of the final wines.
During spontaneous fermentations, a succession of yeast species takes place. Aerobic or low fermentative species (e.g., Pichia, Candida, or Hanseniaspora) and other fermentative yeasts, such as Metschnikowia, Lachancea, Torulaspora, or Zygosaccharomyces, are present in the early stages.
As fermentation progresses, these species are gradually substituted by Saccharomyces cerevisiae, which has higher fermentative power and is more tolerant to ethanol. The interesting features of some of these non-Saccharomyces yeasts include an increase in glycerol content and total acidity, a reduction in acetic acid and ethanol content, the secretion of enzymes, and the production of secondary metabolites that enhance the wine aroma profile, or the biocontrol of spoilage microorganisms.

Objectives:

The mixed inoculation of yeasts presents great potential in the production of new wines that the market demands, such as wines with a lower alcohol content. The objective of this practice is a reduction in ethanol levels during wine fermentation, without increasing the levels of undesirable products in the final wines (undesired flavor and/or aroma).

Applications:

Special mention will be made of methodologies based on the use of different species of non-Saccharomyces yeasts, such as Candida stellata, Lachancea thermotolerans, Metschnikowia pulcherrima, Torulaspora delbrueckii, etc. The use of these strains in fermentations with sequential or simultaneous inoculations, together with Saccharomyces cerevisiae, showed significant results in the reduction of alcohol in wines. Furthermore, in many cases, with positive effects on the quality of the wine. Largely due to the byproducts generated by these yeasts.

The possibility to reduce ethanol production in wines during fermentation involves the use of different yeast strains characterized by lower sugar-to-ethanol transformation rates than Sacch. cerevisiae and the increased production of fermentation by-products (glycerol, 2,3-butanediol, etc.) from the available sugar. The methodologies are based on the use of different species of non-Saccharomyces yeasts, such as Candida stellata, Lachancea thermotolerans, Metschnikowia pulcherrima, Torulaspora delbrueckii, etc.
The use of these strains in fermentations with sequential or simultaneous inoculations, together with Saccharomyces cerevisiae, showed significant results in the reduction of alcohol in wines. Furthermore, in many cases, with positive effects on the quality of the wine. Largely due to the byproducts generated by these yeasts.

Results:

As monoculture inoculation of non-Saccharomyces yeasts has the drawback that most of them are not able to complete the fermentation process, it is required to carry out simultaneous inoculation (joint inoculation of non-Saccharomyces strain and Saccharomyces strain) or sequential inoculation (initial inoculation of the non-Saccharomyces strain and after a period of time the Saccharomyces strain) to produce biomass and by-products, decreasing ethanol formation before addition of S. cerevisiae.
These sequential fermentations produced wines with between 0.5% (v/v) and 1.3% (v/v) lower ethanol concentrations in the wines. In addition, these combinations provided favorable oenological characteristics to wines such as high glycerol proportion, or increased the total acidity with increased concentrations of lactic and acetic acids volatile as well as the production of desirable volatile compounds higher alcohols, and esters with fruity and sweet character. (Garcia et al., 2020; Puskas et al., 2020; Blanco et al., 2021; Zhu et al., 2021)

More informations:

Blanco, P.; Castrillo, D.; Graña, M.J.; Lorenzo, M.J.; Soto, E. (2021) Evaluation of Autochthonous Non-Saccharomyces Yeasts by Sequential Fermentation for Wine Differentiation in Galicia (NW Spain). Fermentation, 7, p. 183. https://doi.org/10.3390/fermentation7030183
García, M., Esteve-Zarzoso, B., Cabellos, J.M., Arroyo, T (2020) 'Sequential Non- Saccharomyces and Saccharomyces cerevisiae Fermentations to Reduce the Alcohol Content in Wine', Fermentation, 6(2), p. 60. https://doi.org/10.3390/fermentation6020060
Puškaš, V. S. Miljić, U. D., Djuran, J. J., Vučurović, V. M. (2020) 'The aptitude of commercial yeast strains for lowering the ethanol content of wine', Food Science & Nutrition, 8(3), pp. 1489–1498. https://doi.org/10.1002/fsn3.1433
Zhu, X.; Torija, M.J.; Mas, A.; Beltran, G.; Navarro Y. (2021) Effect of a Multistarter Yeast Inoculum on Ethanol Reduction and Population Dynamics in Wine Fermentation. Foods. Mar; 10(3): 623. https://doi.org/10.3390/foods10030623

2.1 Endemic grapes : Quartomoro di Sardegna Il Vigneto "Memorie di Vite"

Quartomoro di Sardegna was born from the desire of the oenologist Piero Cella to be able to work in an educational winery where he could research, experiment and produce new oenological solutions starting from the vast range of native vines that the Sardinian viticultural biodiversity is able to offer.
The cellar also wants to be a meeting place, as they defined it, of people, ideas, experiences and cultures aimed to promote the development of the Sardinian wine sector through the production of wines representative of the island's identity.

Objectives:

The creation of the vineyard "Memorie di Vite" (it is a play on words because the word vite in Italian means both lifes and vine) is part of this perspective, a catalog field aimed to safeguard native vines, cultivating them and making wine from grapes in order to be able to enlarge our knowledge on their potential applications in view of the renewed interest in their use for the problem of climate change.

To confirm this, the vineyard harvest is reserved for children, in order to stimulate in them reflections about the importance of local productions and the protection of biodiversity (and native varieties in particular) also as a tool for adapting to climate change.


Piero Cella


"Memorie di Vite" vineyard

List of Sardinian varieties cultivated in the vineyard

Applications:

The conservation and valorization of the Sardinian ampelographic heritage finds a home in the Vineyard of Memories, a space that the oenologist wanted to dedicate to the conservation of the native Sardinian vines that have been cataloged over the years by Agris, the regional agency responsible for research in agriculture in the person of Dr. Lovicu and his working group.
In the vineyard, located in the countryside of Marrubiu - a municipality located in central-western Sardinia - and covering approximately 250 m2, there are 54 vines (all grafted onto the 1103 Paulsen rootstock - one of the most widespread in Sardinia) from the most representative, such as Vermentino, Cannonau and Nuragus up to those unknown to most people and which will all be vinified separately so as to be able to know their peculiarities and their potential.

Results:

From the separate cultivation and vinification of these vines, numerous analytical data will be obtained, useful to understand the behavior in the vineyard and in the cellar, as well as the potentialities of the native Sardinian vines towards the main problems caused by climate change on the island (increasing in late frosts and hailstorms, of highest temperatures on summer days, shortening of the vegetative cycle, decrease in titratable acidity and aromatic content) in order to produce wines that are modern, appreciated by the market and representative of the Sardinian region.


Vignoble "Memorie di Vite" vineyard

More informations:

1- The winery's website.
https://www.quartomoro.it/

2- Piero Cella describes the vineyard of memories project.
https://www.youtube.com/watch?v=HzgFBH4ZPZo

3- The interview released for the Demain project
https://www.youtube.com/watch?v=BCwXt-NRDnQ&t=144s

2.2 Hybrid and resistant varieties

The vine faces many aggressors and in particular diseases such as mildew, powdery mildew or botrytis, which can compromise yield and have a negative impact on the quality of the wine. Faced with these aggressors, it is possible to use natural (copper, sulfur) or synthetic phytosanitary products.
Reducing these products is an objective in the context of agro-environmental transition. There are other solutions to counter the harmful impacts of these diseases. One of them is the planting of grape varieties resistant to these attacks.


© Stéphane Badet, Resistant varieties Plantation at château Dillon

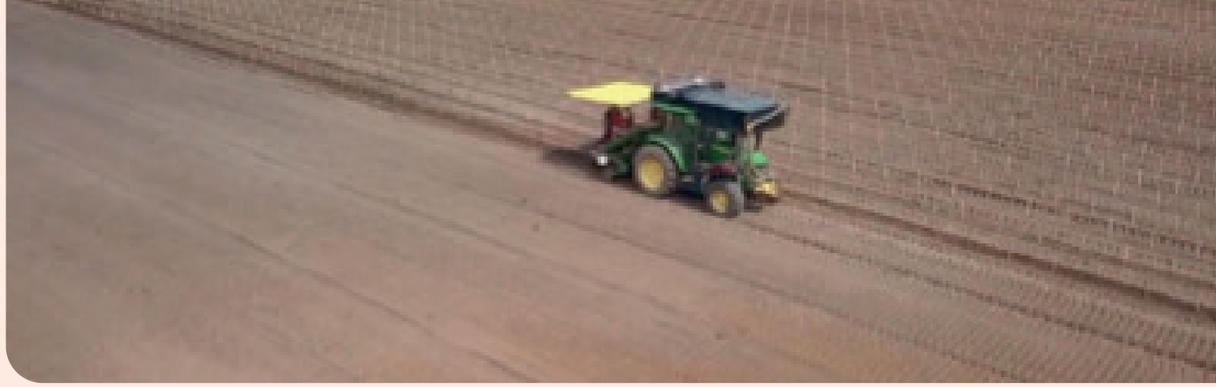
Objectives:

What is a resistant variety? After millennia of human selection, the varietal diversity within the Vitis vinifera species is made up of thousands of grape varieties, presenting a wide range of agronomic and oenological characteristics, but no or very little resistance to major parasites imported from others. continents such as downy mildew and powdery mildew.
In contrast, other wild species of Vitis of American origin (V. riparia, V. rupestris, V. aestivalis, V. cinerea, etc.) or Asian (V. amurensis, V. coignetiae, etc.) carry natural resistance to these pathogens. These mechanisms can be very effective, even constituting a total barrier in the case of certain powdery mildew resistance genes.
The objective of creating resistant varieties is to obtain individuals who have integrated resistance traits from American or Asian vines into the genetic background of European vines. The techniques applied to achieve this introgression call on successive crossings coupled with rigorous selection of descendants. Source IFV https://www.vignevin-occitanie.com/fiches-pratiques/les-varietes-resistantes/

Resistant grape varieties are therefore vine varieties which naturally tolerate attacks better and are less impacted by these diseases. Planting these varieties therefore means that you have to treat the vine less to protect it from these pathogens, particularly fungi.
The choice of more resistant plant material (rootstock and grape variety) will allow the winegrower not only to process less but also to adapt his vineyard to the new climatic conditions announced.

Applications:

These varieties were created by varietal selection. They come from a natural cross between several varieties of vines, making it possible to isolate and then provide the genes responsible for resistance. These are natural hybrids and are not GMOs which remain banned in Europe. The creation and testing of these resistant varieties took many years.
They were also selected based on cultural and oenological performance criteria, to produce quality wines, in line with consumer taste. There are currently several varieties in white and red, such as Floreal, Souvignier, Vidoc, Voltis, Sauvignac, Artaban… These are already authorized for the production of wine for certain appellations. New resistant varieties will arrive and be authorized in the years to come. Source OSCAR https://observatoire-cepages-resistants.fr/les-fiches-cepages-resistants/
Adapting viticulture to climate change will also involve choosing existing rootstocks and grape varieties from other regions or countries which will better withstand the new conditions: temperature, drought, etc.



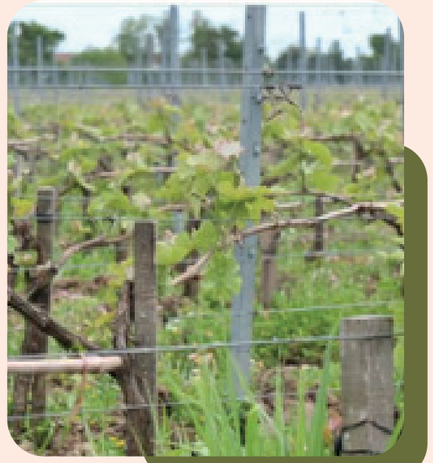
Results:

These resistant grape varieties allow “clean” production, that is to say almost without natural or synthetic fungicide. It is currently estimated that resistant grape varieties make it possible to reduce fungicide treatments by more than 90% Source OSCAR
By eliminating many fungicide treatments, it is also a saving for the winegrower, operators who are no longer exposed to products that could present risks.
Finally, it is the opportunity to maintain a vineyard close to homes and buildings, while maintaining good relations with the neighborhood.
The production of these grape varieties is still poorly understood. We lack perspective on the quality and profiles of wines made from these grape varieties. However, it is possible to note that some of these grape varieties are already used in blending and marketed.

The deployment of resistant grape varieties raises new questions around 3 main issues:
- **the durability of the resistors deployed** and the risk of bypass leading to a reduction in the effectiveness of these resistors;
- **the emergence of new diseases** following changes in protection practices (reduction of inputs);
- **the optimal technical itineraries** to put in place for the cultivation of these grape varieties.

To respond to these challenges, INRA and IFV created the National Observatory for the Deployment of Resistant Grape Varieties (OSCAR) in 2017. This observatory has two main missions:
- **Organize collective monitoring** of deployment in order to anticipate risks linked to the evolution of downy mildew and powdery mildew populations and the emergence of new health issues;
- **Organize the sharing of experience** on the behavior of resistant grape varieties in different growing systems to help winegrowers build these new technical routes.

Source: https://observatoire-cepages-resistants.fr/lobservatoire/qui-sommes-nous/



More informations:

Link to OSCAR Web Site
https://observatoire-cepages-resistants.fr/

Links to technical sheets
https://observatoire-cepages-resistants.fr/les-fiches-cepages-resistants/
https://www.vignevin-occitanie.com/fiches-pratiques/les-varietes-resistantes/

Links to scientific documents
https://www6.bordeaux-aquitaine.inrae.fr/egfv/Ressources/Dispositifs-experimentaux/Parcelle-VITADAPT
file:///L:/T%C3%A9l%C3%A9chargements/TC_22_VitAdapt_RFO_20.pdf
https://www6.bordeaux-aquitaine.inrae.fr/egfv/content/download/4127/45776/version/1/file/VitAdapt_Destrac_vanLeeuwen.pdf

Video: https://vimeo.com/823733602

2.3 Facing climate change Local grape varieties, as a solution

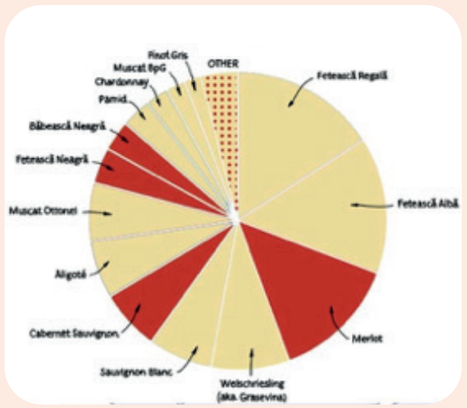
Romania has one of the oldest winemaking traditions in the world, with viticulture spanning over 6,000 years.
Due to the cool and misty climate, the northeastern provinces of Romania are famous for their aromatic white wines. Grape varieties such as Chardonnay and Sauvignon Blanc will be found more easily on the Black Sea coast in the Murfatlar region.
The warmer climatic conditions of the southern regions of Dealu Mare leading to Oltenia, will facilitate the ripening of the grapes and be more favorable to the red grape varieties.
Finally, the Rhineland varieties preferred Transylvania and produced wines with a strong Germanic influence there.
Romanian viticulture, like many other wine-growing regions in the world, is hit by climate change and must adapt.
In Romania, winegrowers are increasingly faced with spring frost and summer drought.

Objectives:

Spring frost can hit all horticultural, vegetable and fruit production during the restart of vegetation after winter, and lead to a significant loss of harvest.

Drought is an extreme phenomenon with multiple effects that can weaken agricultural production, food security, energy security or river transport. Significant hydrological variations directly impact the distribution of groundwater and surface water resources in time and space.

The development of Romanian viticulture has been based over the centuries on very varied terroirs, a classic continental climate, with hot and dry summers, extremely cold winters and numerous local varieties which make up the typicality of Romanian wines. But these local varieties also have intrinsic qualities of adaptation to different climatic accidents, such as frost or drought. Presenting themselves as both a solution to climate change and a vector of differentiation on the global wine market, these indigenous grape varieties are finding favor in the eyes of Romanian winegrowers.



Applications:

Adapting to increased and more violent episodes of drought requires improving agricultural practices by taking into consideration a series of agronomic principles, allowing maximum conservation of water in the soil, by increasing, for example, the rate of organic matter or the installation in the fall of plant covers between the rows. In order to best adapt his vineyard, the winegrower can also choose local grape varieties with good resistance to drought.

Faced with spring frost, as well as drought, the Romanian winegrower will be able to plant varieties resistant to summer water deficit and adapted to his specific production conditions. It may also influence other factors such as the choice of planted plots. Planting on south, southeast or southwest facing slopes and hills will be recommended. Planting in colder valleys or depressions should be avoided.

Results:

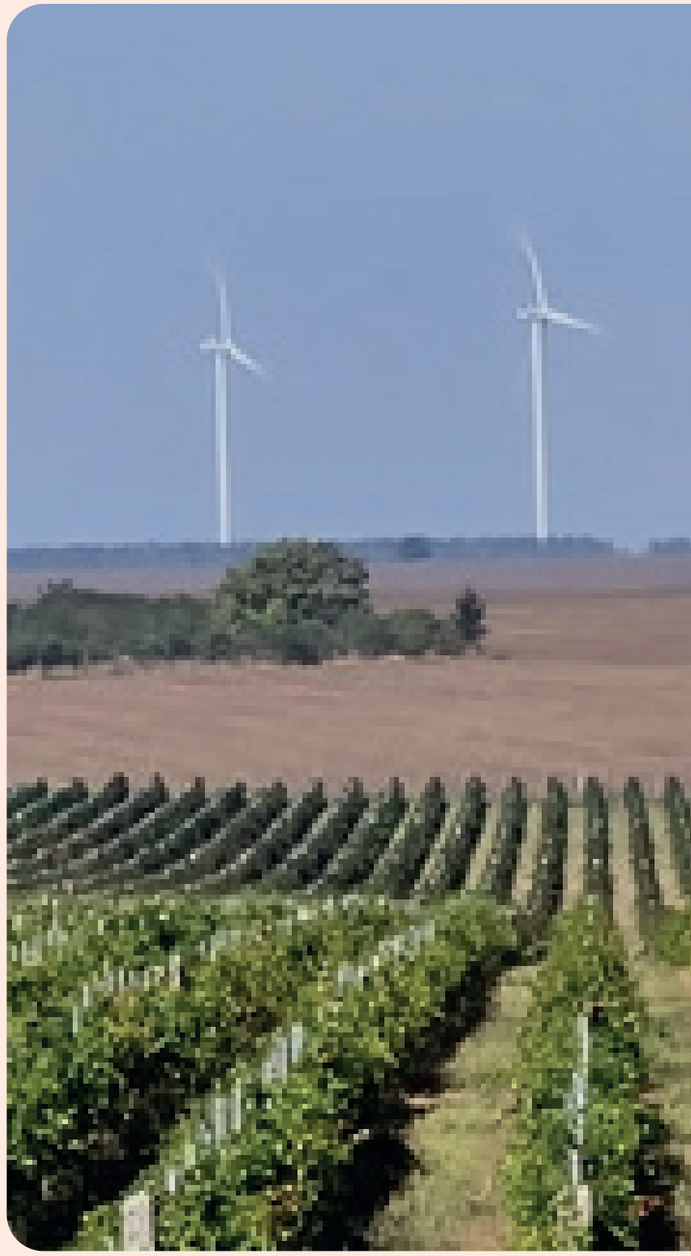
The frost and/or drought resistant varieties most used in Romania are:

Fetească Albă, a clonal variation of the Fetească neagră variety, appeared in Moldova and today is cultivated in most parts of Romania, the Republic of Moldova and Hungary. The Fetească variety is vigorous, of average fertility, and resists frost and drought well. The berries are round, medium to small in size, yellow-green in color. The wines have aging potential and are distinguished by their finesse and balance. Their olfactory and taste profile allows us to find aromas of citrus fruits and linden flowers, which can evolve into wild flowers, hay, or even ripe apricots.

Frâncușă is an old Romanian grape variety grown for centuries in the Cotnari vineyard. The grape variety has medium-sized adult leaves, with dark green, slightly wavy blades and edges turned towards the upper surface. The grapes are medium to large, cylindrical-conical, with berries often placed in clusters. The berries are medium spherical in shape, with thin yellow-green skin, juicy flesh and a grassy taste. This grape variety is particularly appreciated by Romanian winegrowers because it is very resistant to drought.

Fetească Regală is one of the most famous and sought-after wine grape varieties in Romania. It was discovered after 1920 in Transylvania, near Sighişoarae. Recent DNA analyzes reveal that it would come from a natural cross between Feteasca Albă and Frâncușă, giving it the qualities of the 2 varieties. The variety's operating areas extend throughout the country. Fetească Regală is quite resistant to frost and fungal diseases but sensitive to botrytis. The flowers of Fetească Regală are hermaphrodite, the variety being self-fertile. At full maturity, Fetească Regală produces, thanks to its fine and elegant tannins, and depending on the type of aging, more or less full-bodied wines, with intense aromas and great aging potential. It is also a grape variety capable of producing exceptional sparkling wines.

Fetească Regală and Fetească Alba are currently the most planted grape varieties in Romania, a choice made by Romanian winegrowers, as much for their resistance to heat and cold as for the quality of the wines they produce.



More informations:

Links to official web sites giving informations, and promoting romanian local grapes

https://www.madr.ro/comunicare/7664-madr-pune-la-dispozitia-fermierilor-un-ghid-de-bune-practici-agricole-privind-efectele-schimbarilor-climatice.html
https://www.madr.ro/ghid-de-bune-practici-agricole.html
https://www.madr.ro/docs/cercetare/Rezultate_activitate_de_cercetare/INCDBH_Stefanesti_Arges.pdf
https://www.madr.ro/docs/cercetare/Rezultate_activitate_de_cercetare/SCDVV_Iasi.pdf
https://agrointel.ro/77566/rezistenta-la-inghet-a-vitei-de-vie/
https://www.crameromania.ro/soiuri-de-struguri/4/

3.1 Biocontrol solutions: techniques and applications

The effect produced by climate change and the concern of European society for the environment and the health of producers and consumers has led the European Commission to policies that implement more sustainable production models and drastic reduction of synthetic pesticides.
The European Green Deal, the Biodiversity Strategy for 2030 and the "Farm to Fork strategy" seek to become a reality this change in the 2030-2050 horizon. Viticulture is a fundamental sector in the economy of the European Union and must be prepared and adapted to these changes.
Therefore, integrated vineyard management of pest and diseases and the use of biological control agents is one of the fundamental tools to achieve these objectives in the vine and wine sector.

Objectives:

An accurate knowledge of the biological cycle of pests and diseases in the vineyards of our region. Control through integrated management of pests and diseases, specially using Biological Control Agents. Moreover, the isolation of biological control agents native to the vineyards of each region (microorganisms with the capacity to control pests and diseases and adapted to specific edaphoclimatic conditions) and their subsequent application in the vineyard.

Applications:

A practical knowledge of the biological cycles of pests and the use of biological control agents will allow a correct health status of the vine plants, ensuring longer-lived plantations, healthy, productive and safe harvests. This will lead to a reduction of the pest population to its optimal economic minimum.

Results:

Study of biological cycle of pests and diseases and its integrated management.

- Biological cycle of insect pest Xylotrechus arvicola has been identified in León province. Different factors (climatic, management, environment...) have an important weight over flight curve. So that, every year it is important to evaluate traps installed in vineyard to determine the peak in order to be effective.
- In our region, different types of traps have been evaluated to determine the optimal one; also, different types of lures (kairomones and pheromones) have been tested to increase the number of captures.

Isolation and application of biological control agents.

- A survey from many vineyards in Castilla y León region have been done in order to isolate autochthonous biological control agents (specifically Trichoderma) from soil vineyards and vine plants.

Inoculation in root system of vine plants

Spraying over prunning wounds

- Laboratory tests have been performed in order to identify the best isolates that performed the best results against pathogens that cause grapevine trunk diseases.
- Fungal isolates of the Trichoderma genus are available as a biocontrol tool in our region. Specially, they are adapted to the climatic and soil conditions of each terroir.
- The characteristics of biocontrol agents (Trichoderma) have been studied as well as their implication in climate change.
- The use of biocontrol agents has been applied against the Xylotrechus arvicola insect pest.
- Field application trials are being carried out to protect pruning wounds and the root part of vine plants against fungal wood diseases.

More informations:

A deep knowledge of biological cycle of pest and diseases and its integrated management.

Identification of biological parameters of the insect pest Xylotrechus arvicola:
1. https://oeno-one.eu/article/view/1880
2. https://onlinelibrary.wiley.com/doi/epdf/10.1111/1748-5967.12249?src=getftr
3. https://academic.oup.com/jee/article-abstract/109/3/1226/2648760?redirectedFrom=fulltext
Climatic effects over the biology of the insect-pest Xylotrechus arvicola:
4. https://onlinelibrary.wiley.com/doi/epdf/10.1002/ps.6928?src=getftr
Biological control of Xylotrechus arvicola:
5. https://academic.oup.com/jee/article/111/6/2585/5085270
6. https://www.agenciasinc.es/Noticias/Metodos-biologicos-para-combatir-el-tornillo-de-la-vid
Integrated pest management of Xylotrechus arvicola:
7. https://www.unileon.es/noticias/el-cultivo-de-vid-en-la-provincia-de-leon-es-puntero-y-su-salud-tambien-debe-serlo
8. https://onlinelibrary.wiley.com/doi/epdf/10.1002/ps.4491?src=getftr
9. https://onlinelibrary.wiley.com/doi/10.1111/ajgw.12324
10. https://www.murcia.com/empresas/noticias/2020/12/18-la-trampa-murciana-crosstrap--finalista-en-los-premios-de-innovacion-de-la-plataforma-tecnologica-de.asp
Isolation and application of Biological Control Agents:
Isolation of Biological Control Agent (Trichoderma) and its relationships to the environment and management.
11. Isolation from soil
https://www.mdpi.com/2223-7747/12/4/887
12. Isolation from plant
https://www.mdpi.com/2073-4395/11/3/446
Figure 2. Isolation of authoctonous strains from vineyards. A) isolation from vine plants. B) Isolation from soil of vineyards.
Evaluation of biological control agent Trichoderma against pathogens that cause grapevine trunk diseases:
13. https://www.frontiersin.org/articles/10.3389/fpls.2020.01170/full
Figure 3. Laboratory work. A) Isolates of Trichoderma strains over PDA media growth and B) Assay in in vitro conditions over grapevine canes.
Evaluation of factors that enable a successful colonization of vine plants by biological control agents:
14. https://www.mdpi.com/2073-4395/11/9/1771

3.2 Spreading techniques and dose reduction

The vine is among the plant productions that consume the most phytopharmaceutical products due to the numerous pests it faces. In viticulture, yields and the production of quality grapes are strongly dependent on the control of phytosanitary protection.

In France, more than 80% of the phytosanitary products used are fungicides, the use of which is almost systematic to fight against downy mildew, powdery mildew or other aggressors. The remaining 20% are insecticides, herbicides, etc. for which there are alternative solutions, such as mating disruption, tillage or viti-grazing (see fact sheet).

The number of treatments is influenced by climatic conditions but it also results from practices to control the vigor of the vines as well as commercial issues.

Objectives:

Faced with certain pests and the management of the vineyard is done in sustainable, organic, biodynamic agriculture... there is a virtual obligation to use synthetic or natural phytosanitary products (copper, sulfur).

The ecological, social, societal or economic issues (cost of treatments) are to use as few products as possible and to make them as effective as possible.

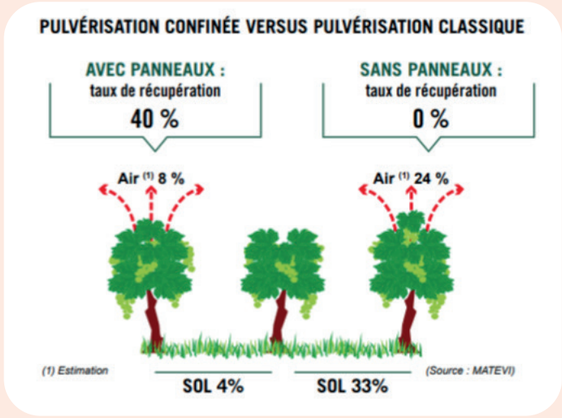
The objectives of good application of products are to best target the vegetation to be protected and to control drift during phytosanitary treatments.

Applications:

To achieve these objectives of reducing doses of phytosanitary products applied to the vineyard, the winegrower has several tools at his disposal:
Decision Support Tools, which allow the winegrower to make the decision to treat or not, depending on the weather (past and future, the disease cycle, the intensity of the attack, the risk incurred by production, etc.) and to determine the dose of products to apply.
The Air Jet sprayer equipment and the right choice of nozzles make it possible to calibrate the size of the desired drop (avoid fine drops with high dispersion)
Adjusting the sprayer statically before treatment contributes to good positioning of the nozzles, thus getting closer to the target to be treated.
The equipment in so-called “recovery” panels or so-called confined spraying creates a sort of mobile tunnel around the rows of vines, thus preventing drift (air, soil) and allowing the recovery of products not applied to the leaves.

Results:

The results observed are a significant reduction in the doses of phytosanitary products applied to the vine, but also through better application of the products (choice of periods, areas of application, etc.) an improvement in the effectiveness of these products.
Finally, through confined spraying, it is possible to recover a large quantity of products and to strongly limit «drift», that is to say the dispersion of these products towards undesired and undesirable areas (transport and dissemination by air, penetration into the ground)
These solutions therefore make it possible to significantly limit the use of phytosanitary products. These devices can be supplemented by hedges (see viti-forestry sheet) acting as a natural panel preventing drift towards homes for example, or protective nets.
Breakthrough technologies such as Viti-tunnel (see sheet) according to the principle “no rain, no disease and therefore no treatment” will also probably be a future solution for Non-Treatment Zones or for plots particularly sensitive to fungal diseases.
This control of treatments also makes it possible to limit the number of tractor passages, reducing diesel consumption, soil compaction, etc.



More informations:

Links to professional documentation for a better spraying mangement and reduction dose

https://www.vignevin-occitanie.com/la-pulverisation-dans-le-vie/
https://www.matevi-france.com/viticulture/pulverisation-foliaire/2092-grandes-familles-de-pulverisateurs.html
https://www.vignevin.com/wp-content/uploads/2020/01/Itin16_PulveVitiDurable1.pdf
https://www.vinopole.com/recherches-experimentations-vitivinicoles/agro-ecologie/diminution-des-intrants/agro-equipement/maitriser-la-pulverisation-protection-du-vignoble/
https://www.vinopole.com/wp-content/uploads/2022/07/33_Livre-Blanc-Pulve_Janvier_2022.pdf
https://pays-de-la-loire.chambres-agriculture.fr/fileadmin/user_upload/Pays_de_la_Loire/022_Inst-Pays-de-la-loire/RUBR-RD-innovation/Productions-vegetales/IRD_REPP_AIR/REPP_AIR_fiche_23_Amenager_haies_pour_limiter_derive.pdf
https://www.vignevin.com/article/la-pulverisation-confinee-en-viticulture/
Link to video about management spraying
https://www.youtube.com/watch?v=4mG7z9_-GjM

4.1 Vititunnel

Viti-Tunnel is an example of disruptive innovation driven by the start-up MO.DEL, with a view to integrating the Vine-Wine sector into the agroecological transition and adaptation to climate change.
https://viti-tunnel.com/

Objectives:

Many companies and start-ups in collaboration with the IFV and INRAE research organizations are offering solutions to address the challenges of climate change and the agroecological transition. Viti-tunnel is a retractable tunnel device for automatically sheltering rows of vines during rain and extreme weather events.
This innovative system has been tested for 4 years in a network of 10 partner properties in Gironde, including the EPL Bordeaux-Gironde with its estate, Château Dillon. This experiment carried out by MO.DEL is also carried out in conjunction with researchers from IFV-Vinopôle 33 and the Gironde Chamber of Agriculture.
Based on the simple principle “no rain, no disease”, it prevents the development of fungal diseases, particularly mildiew. It therefore avoids the majority of Chemical treatments.

Applications:

Viti-tunnels are fixed systems installed on the vines with retractable tarpaulins, protecting the vines, like a tunnel or a greenhouse, from rain and possibly climatic accidents, such as hail, frost, etc.
Deployment is automatic and is triggered by rain sensors.
Electric motors will allow the opening and covering of the vines in a few seconds. And once the rain is over, the system is triggered again to reopen the tarpaulins and therefore allow the vegetation to continue to benefit from the sunshine.
The vine thus protected from the rain is much less exposed to the risk of fungal diseases for which humidity is a main factor in their development.

The opening and closing of the viti-tunnels is done by electric motors which are themselves powered by the solar panels, if connection to the conventional electricity network is made impossible by the distance of the plots.

It is also possible to imagine a deployment triggered by the winegrower himself from his smartphone in order to prevent a violent climatic episode.

Results:

Allowing the protection of vegetation during the rains, viti-tunnel tests seem to prove that it is possible to have a reduction of more than 90% in fungicide treatments.
The installation could therefore be imagined on plots particularly exposed to fungal diseases, mildew in particular, plots close to homes (Untreated Zones), or in grand cru where the issues of protecting the harvest are important.
Viti-tunnel therefore makes it possible to secure yields. The potential quality will not be altered by fungal aggressors. By reducing treatments by more than 90%, Viti-tunnel also limits soil compaction and biodiversity.
Its use in different situations has also shown its effectiveness in protecting against hail, frost and weather damage.
Even if Viti-tunnel saves many fungicide treatments, the question of the cost of the investment remains a barrier at present. The Viti-tunnel experiment on the 10 wine properties also raised a certain number of regulatory questions (authorization in AOP), integration into the landscape, circulation of work tools and mechanization.

More informations:

Link to MO.DEL start-up
https://viti-tunnel.com/

Links to professionnal articles
https://www.vitisphere.com/actualite-96205-20-par-metre-de-vigne-protegee-du-mildiou-et-du-gel-pour-viti-tunnel.html
https://www.vitisphere.com/actualite-97520-le-viti-tunnel-tres-prochainement-deploye-sur-les-vignes-.html

Link to video
https://www.youtube.com/watch?v=ujzFX70dLmA

4.2 Robots

Viticulture robots developed by several start-ups are disruptive innovations, which can provide solutions with a view to integrating the Vine-Wine sector into the agroecological transition and adaptation to climate change.

© Stéphane Badet

Objectives:

As in many other economic sectors, robotics in viticulture is developing. The robots proposed by many companies and start-ups have passed the stage of tested prototypes. They now appear mature and reliable and many wineries are interested and ready to invest.

Applications:

Several operations in the vineyard can currently be robotized, such as soil and grass maintenance (management of mowing, weeds, etc.), harvest assistance, pruning or data acquisition. Robotic spraying solutions are also being developed.
These robots are generally electric and autonomous. The configuration (adjustments, forward speed, etc.) and management are entirely computerized and can be done on a tablet or mobile phone directly on the plot. The mapping of the plots that the robot can work with, done beforehand, is integrated into the control software and allows the robot to find its way by GPS positioning in the plots.

Results:

The robots currently in service have already demonstrated their efficiency and reliability.

- **On an environmental level,** robots are a gateway to practices using fewer inputs, while removing constraints linked to working time, for example in the management of grass cover. As one manufacturer says, “Herds of robots to replace herbicides!” «. It is possible to add that robots provide a generally fossil fuel-free alternative by replacing the traditional diesel tractor. Their very limited weight compared to existing tractors and their less fuel-efficient engine are an asset for reducing fuel costs on the farm and soil compaction despite more frequent passages. This will require that the majority of heavy operations in the vineyard be automated.
- **On a social and societal level,** we can imagine that the arrival of robots in viticulture will reduce arduousness, strengthen the attractiveness of vineyard professions, and attract young people interested in these new technologies, reorganize construction sites and redistribute time of work towards operations with higher added value. The robot maintenance and control team will need to be better trained. The robot can also be seen as a solution to the lack of tractor drivers and vineyard workers who are considered to be jobs in shortage. A robot also provides flexibility with regard to labor legislation. He can in fact work perfectly independently on Sundays or at night.

It is generally silent and has a number of safety warnings, probably making it less dangerous than a conventional tractor, qualities which will be appreciated by operators and local residents.

- **On an economic level,** the question of the profitability of the investment will be monitored in the years to come, and will probably involve the versatility of robots. The multiplication of jobs possible by robots (like current tractors) will make them more profitable. To do this, the robots will need to be able to carry out other tasks (sampling, processing, data acquisition, etc.) to be able to amortize these heavy investments. We also currently lack perspective on the possible duration of use and therefore depreciation of the robots placed on the market, on the cost of maintenance and repairs. A robot must offer a price/work capacity ratio allowing it to be profitable compared to the same operations carried out with a tractor. The profitability of the robot will be all the more obvious if it is truly versatile and capable of carrying out several tasks, at the same time or successively.

Depending on the power, the actual autonomy before recharging or the usage model, the surface area to be allocated to the robot for a return on investment will vary. The first estimates give a minimum surface area of 25 ha. Regarding the typology of use, given the constraints of moving a vehicle without a driver, the plots dedicated to robots will be those to which it will be easy to bring them, then recover them to recharge them.
Farms with grouped plots will therefore be easier to equip with a robot.
It is likely that the farm tractor will not be completely abandoned, but we will witness a distribution of tasks between robot and tractor defined by the accessibility of the plots, and allowing a redistribution of working time.
Source IFV (https://www.vignevin-occitanie.com/fiches-pratiques/la-robotique-en-viticulture/)

In the years to come, there will be an opposition of mechanization models, between the traditional players “tractor + tool” whose entire development is based on the dogma “more power for more surfaces and more simultaneous work” and the start-ups -up of robotics which highlight a possibility of changing approach: more smaller machines and less effort, more interventions.

Finally, the challenge of safety and regulations remains at the heart of discussions in the ROBAGRI association, which brings together institutes, manufacturers, developers and specifiers to define new standards for this new form of mechanization.

More informations:

Link to technical sheets IFV and professional articles

https://www.vignevin-occitanie.com/fiches-pratiques/la-robotique-en-viticulture/
https://www.reussir.fr/vigne/yanmar-robotise-la-pulverisation-viticole
https://www.reussir.fr/vigne/des-robots-porteurs-suiveurs-pour-menager-ses-peines-la-vigne

Links to robots companies web sites

https://www.robagri.fr/
https://vitibot.fr/
https://www.naio-technologies.com/
https://www.vitirover.fr/
http://www.mialtech.com/
http://wall-ye.com/index-2.html
https://www.sitia.fr/trektor-tracteur-agricole-autonome/
https://www.yanmar.com/fr/campaign/2021/10/vineyard/
https://exxact-robotics.com/gofar-x-fira-le-premier-tracteur-viticole-a-hydrogene-au-monde-est-arrive/

4.3 Utilisation du drone dans les vignes

Les drones constituent une avancée innovante pour la capture et la localisation précise d'informations en provenance des vignobles et sont un outil fondamental pour la prise de décision en matière de culture et contribuent ainsi à l'inscription du secteur vitivinicole dans la transition agro-écologique et l'adaptation au changement climatique.

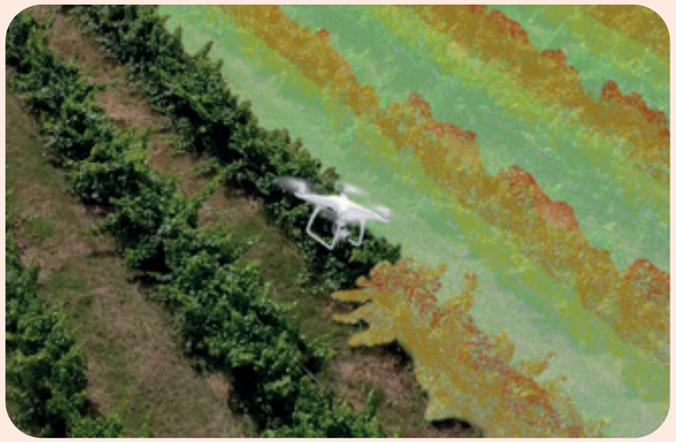
Objectives:

L'utilisation de drones génère des images très précises de la végétation et du sol dans les vignobles. De plus, en survolant l'ensemble du cycle végétatif, ces images permettent un suivi continu. Ainsi, le viticulteur pourra connaître rapidement l'état de chaque portion du vignoble et à chaque stade phéologique de la vigne. Grâce à ces informations, le viticulteur pourra décider quand et où agir rapidement et efficacement.

Drone camera captures high-resolution images of a vineyard. Low altitude oblique image taken from a drone in a vineyard located in Cacabelos (DO Bierzo -vine Designation of Origin; Northwest of León- Spain: coordinates 42.606062, -6.705882 WGS84).

Applications:

Les drones ont de nombreuses applications en viticulture, tant pour la collecte de données que pour l'action directe dans le vignoble. Les données capturées à l'aide d'un drone permettent de créer des cartes très précises du vignoble sur lesquelles on peut représenter la vigueur végétative, identifier le stress, les caractéristiques du raisin (teneur en sucre, poids du raisin, etc.) et créer des modèles 3D des vignes. D'autre part, il est également utilisé comme outil d'action directe pour la prévention du gel, l'application efficace de produits phytosanitaires, etc.
Les seules limites des drones sont liées aux autorisations de vol, bien qu'il existe des réglementations légales dans tous les pays.



Drone camera captures high-resolution images of a vineyard. Image capture simulation in a vineyard located in Cacabelos (DO Bierzo -vine Designation of Origin; Northwest of León-Spain: coordinates 42.606062, -6.705882 WGS84).

Results:

L'utilisation de drones peut aider les viticulteurs à s'adapter au nouveau scénario provoqué par le changement climatique. D'une part, les drones capturent des données à haute résolution qui peuvent aider à la prise de décision et, d'autre part, ils peuvent être des instruments actifs qui optimisent les techniques de culture.

Outil d'aide à la décision
Les images multispectrales acquises par la caméra d'un drone permettent de créer une carte de l'état végétatif de chaque partie du vignoble. Grâce à ces informations, il est possible de :

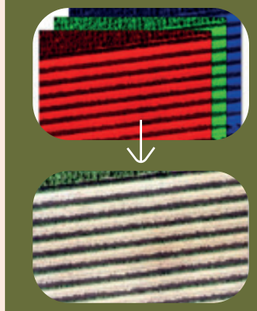
- **Identifier et localiser** les zones présentant des problèmes de stress : manque d'eau, affliction de parasites et de maladies, carences nutritionnelles, dommages dus à des phénomènes météorologiques défavorables.
- **Différencier** la couverture du sol et le couvert végétal de la vigne.
- **Zoner** les vignobles en définissant des parcelles pour une gestion différenciée.
- **Estimer** le rendement et la qualité des raisins récoltés.
- **Planification** de vendanges échelonnées pour récolter les raisins au moment optimal et élaborer les vins programmés par la cave.
- **Planification** optimale des calendriers et des doses d'irrigation, ainsi que d'autres tâches culturales.

Grâce aux images à haute résolution, il est possible de réaliser un modèle 3D très détaillé de l'ensemble du vignoble dans lequel le volume, la hauteur et la largeur du couvert végétal peuvent être déterminés, ce qui permet de calculer très précisément les doses de produits chimiques (pesticides, engrais, etc.), améliorant ainsi la durabilité du système.
Ces données peuvent être prises à un moment précis ou un suivi continu peut être programmé tout au long de la saison de croissance.

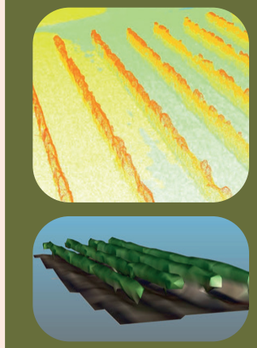
Ces informations permettent au viticulteur de détecter les problèmes à temps et d'agir rapidement, efficacement et localement.

Un outil d'action directe dans le vignoble
D'autre part, les drones sont également utilisés comme outils d'action directe et consomment moins de ressources que les machines conventionnelles. Ainsi, il existe des expériences dans lesquelles les drones sont utilisés pour prévenir le gel, car ils sont capables d'évacuer l'air lorsque les températures tombent en dessous du seuil établi. Une autre ligne de travail est l'application de produits chimiques, car il est possible de réaliser des pulvérisations très efficaces, avec un faible volume de matière active et en atteignant des zones très difficiles d'accès par les méthodes traditionnelles. Ils sont également utilisés pour prévenir les pertes de raisin causées par les oiseaux.

Les drones sont donc des outils qui permettent de lutter contre les phénomènes défavorables et d'appliquer des produits chimiques de manière plus durable et plus efficace.



Drone multispectral imaging allows visualization of data from the visible and infrared spectrum. Multispectral image captured in a vineyard located in Pieros (DO Bierzo -vine Designation of Origin; Northwest of León-Spain: coordinates 42.614800, -6.758235WGS84).



3D models of vineyards. Example of a raw point cloud of a vineyard located in Pieros (DO Bierzo -vine Designation of Origin; Northwest of León-Spain: coordinates 42.614800, -6.758235WGS84).

More informations:

Web sites accessibles en Juin 2023
William Metz on the Potential of Drones in Precision Viticulture (video) https://www.youtube.com/watch?v=7wzIDWBkzgA
Unmanned aerial vehicles in viticulture (blog) https://www.ciencia-e- vinho.com/2021/01/24/unmanned-aerial-vehicles-in-viticulture/
Drones make a difference in professional viticulture (blog) https://tecnitop.com/los- drones-marcan-la-diferencia-en-la-viticultura-profesional/
How drones can improve winemaking (blog) https://www.terraview.co/how-drones- can-improve-winemaking/
Are flying vineyard drones creating better wine? (blog) https://www.wineenthusiast.com/culture/wine/are-flying-vineyard-drones-creating- better-wine/
eVineyard. Field experiment: Can UAVs (drones) be used to prevent frost damage in the vineyard? (blog) https://www.evineyardapp.com/blog/2022/04/05/field- experiment-can-uavs-drones-be-used-to-prevent-frost-damage-in-the-vineyard/
How effective are drones for spraying? (blog) https://www.internationalwinechallenge.com/Canopy-Articles/how-effective-are- drones-for-spraying.html
Special Issue «remote sensing in viticulture» (paper collection) https://www.mdpi.com/journal/remotesensing/special_issues/viticulture
Vineyard Variability Analysis through UAV-Based Vigour Maps to Assess Climate Change Impacts (paper) https://www.mdpi.com/2073-4395/9/10/581
Operational study of drone spraying application of phytosanitary products in vineyards (paper) https://doi.org/10.6036/10230
Psychological warfare in vineyard: Using drones and bird psychology to control bird damage to wine grapes (paper) https://doi.org/10.1016/j.cropro.2019.02.025
How drones are helping with sustainability in the wine industry (blog) https://www.droneblog.com/how-drones-are-helping-with-sustainability-in-the- wine-industry/
Vineyard Variability Analysis through UAV-Based Vigour Maps to Assess Climate Change Impacts https://www.mdpi.com/2073-4395/9/10/581

4.4 Copernicus

Satellite images cover large areas, have been collected since the 1970s-1980s, are systematic (collected at the same places and at the same times) and are accessible to all users.

Climate change affects the wine-growing terroir, that is to say the soil-climate-vine-crop system: the vegetative period of the vine is longer and the phenological stages are earlier, maturation is earlier and yields and characteristics of the grapes are different. In addition, the risk of early frosts and the appearance of new diseases and pests increases. Some studies predict that it will no longer be possible to cultivate vines in certain current wine-growing regions and at the same time show that new wine regions will emerge.

Objectives:

Satellite imagery can help wine growers make decisions to adapt to climate change. Sensors mounted on satellite platforms capture different types of data that can be used to optimize the location of new vineyards and make decisions on works and actions to be carried out in the vineyards in production.

Applications / Results:

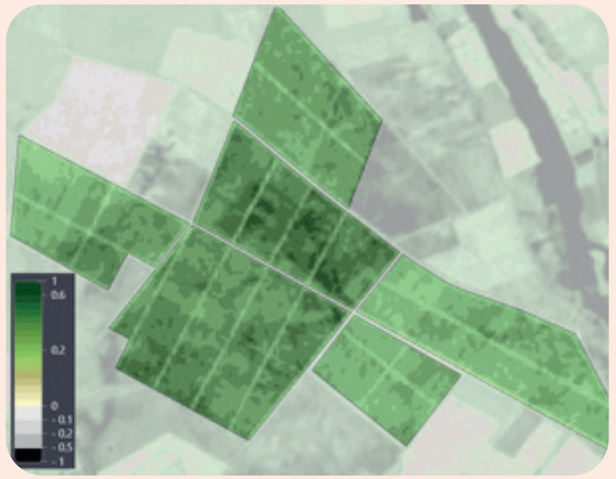
A tool to locate new vineyards
Some sensors (radar and lidar) mounted on satellites have been designed to accurately model the orography of the Earth's surface. This information makes it possible to generate digital terrain models from which it is possible to determine the altitude, slope and orientation of the plots. This information is essential for finding new grape growing areas that are cooler (higher altitude), receive adequate solar radiation (better orientations), and have more moisture in the soil (valleys and depressions).

A decision-making tool in matters of culture
Multispectral sensors make it possible to create maps of the vegetative state of the vineyard and its spatial variations. With this information, it is possible to

- **Identify and locate** areas with stress problems: lack of water, pests and diseases, nutritional deficiencies, damage due to adverse weather phenomena.
- **Zone** the vineyards, by defining plots for differentiated management.
- **Estimate** the yield and quality of the harvested grapes.
- **Planning** a staggered harvest to create the wines programmed by the winery.
- **Optimal planning** of schedules and doses of irrigation, fertilization and phytosanitary products.

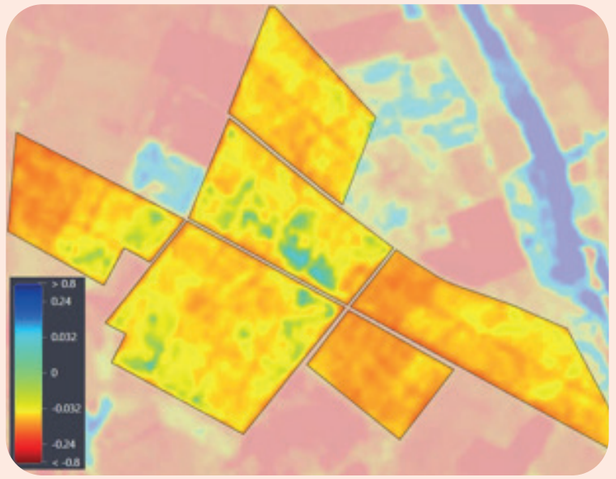
These data are collected periodically and systematically, so that time series can be used to establish accurate prediction models. This information allows the winegrower to detect problems in time and act quickly, efficiently and locally. Indeed, there are platforms that offer viticulture support services based on satellite images, climate information and artificial intelligence, and which operate almost in real time.

Tools to act
The development of harvest forecasting models, based on satellite imagery and climate data, as well as market analysis tools, provides information for investors to make decisions regarding the wine market.



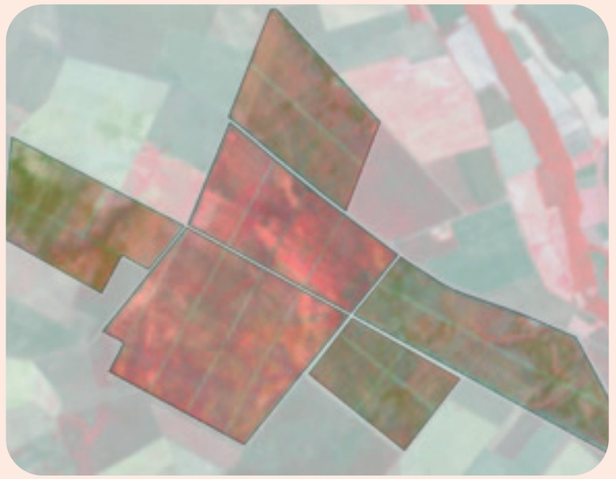
Normalized Difference Vegetation Index (NDVI) of a vineyard located in Gordondello (León-Spain: coordinates 42.138798, -5.426597 WGS84) based on a Sentinel 2 image of 25 June 2023.

The Normalized Difference Vegetation Index is a simple but effective index for quantifying green vegetation. It is a measure of vegetation health based on how plants reflect light at certain wavelengths. NDVI index values are between -1 and 1. Negative NDVI values (values close to -1) correspond to water. Values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Low and positive values correspond to shrubs and grasslands (around 0.2 to 0.4), while high values indicate temperate and tropical rainforests (values close to 1). (Source : https://apps.sentinel-hub.com/eo-browser/)



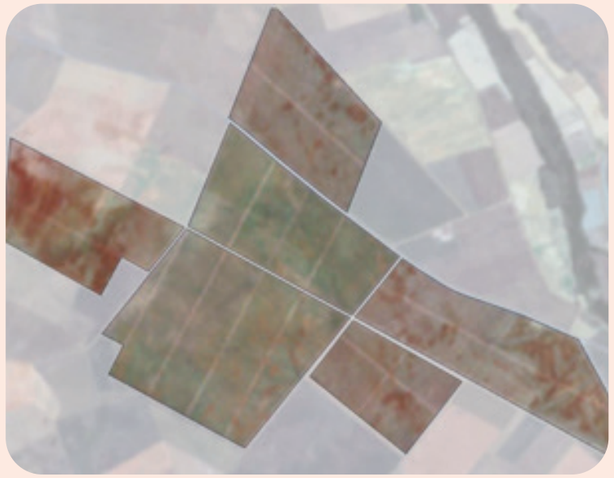
Normalized Difference Vegetation Index (NDVI) of a vineyard located in Gordondello (León-Spain: coordinates 42.138798, -5.426597 WGS84) based on a Sentinel 2 image of 25 June 2023

The Normalized Difference Humidity Index (NDMI) is used to determine the water content of vegetation and monitor droughts. The range of IMDN values is -1 to 1. Negative IMDN values (values close to -1) correspond to infertile soil. Values close to zero (-0.2 to 0.4) generally correspond to water stress. High and positive values correspond to high vegetation cover without water stress (around 0.4 to 1). (Source : https://apps.sentinel-hub.com/eo-browser/)



False color composite of a vineyard located in Gordondello (León-Spain: coordinates 42.138798, - 5.426597 WGS84) based on a Sentinel 2 image of 25 June 2023

A false-color composite uses at least one non-visible wavelength to image Earth. False color composite using infrared, red and green bands is very popular (a band is a region of the electromagnetic spectrum; a satellite sensor can take images of the Earth in different bands). False color composition is most often used to assess plant density and health because plants reflect near-infrared and green light, while they absorb red light. Cities and exposed soils are gray or tan, and water appears blue or black. (Source : https://apps.sentinel-hub.com/eo-browser/)

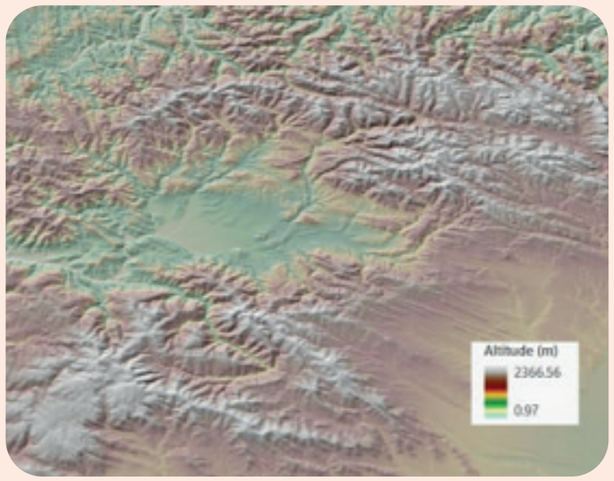


True color composite of a vineyard located in Gordondello (León-Spain: coordinates 42.138798, - 5.426597 WGS84) based on a Sentinel 2 image of 25 June 2023

Sensors carried by satellites can take images of Earth in different regions of the electromagnetic spectrum. Each region of the spectrum is called a band. Sentinel-2 has 13 bands. Real-color composite images use the red, green, and blue visible light bands in the corresponding red, green, and blue color channels, resulting in a natural-colored product that is a good representation of the Earth as it is. that man would see it naturally. (Source : https://apps.sentinel-hub.com/eo-browser/)

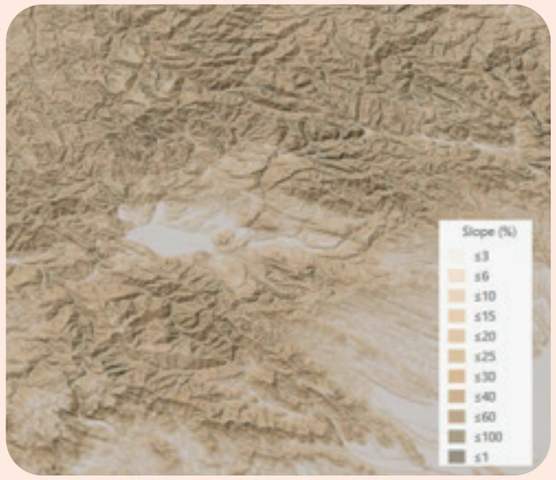
False Color Urban composite of a vineyard located in Gordondello (León-Spain: coordinates 42.138798, -5.426597 WGS84) based on a Sentinel 2 image of 25 June 2023

This composite is used to more clearly visualize urbanized areas. Vegetation is visible in shades of green, while urbanized areas are represented by white, gray or purple. Soils, sand and minerals are depicted in a variety of colors. Snow and ice appear dark blue, and water appears black or blue. Flooded areas are shown in very dark blue, or even black. The composite image is useful for detecting forest fires and volcano calderas, as they are depicted in shades of red and yellow. (Source : https://apps.sentinel-hub.com/eo-browser/)

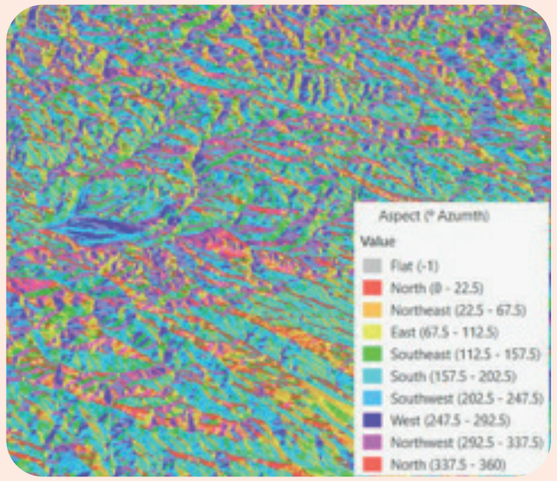


Digital Terrain Model (DTM) of Bierzo -vine Designation of Origin (Northwest of León-Spain: coordinates 42.547166, -6.599039 WGS84)

Un DTM comprend des valeurs d'altitude du terrain.



Map of the Bierzo slope - Controlled Designation of Origin (North-West of León-Spain : coordonnées 42.547166, -6.599039 WGS84)



Map of the appearance of the Bierzo vine - Controlled Designation of Origin (North-West of León - Spain

More informations:

Web sites accessible in june 2023
Clim4Vtis : Mitigating the impact of climate change for European viticulture
(projet EU Horizon 2020) https://clim4vitis.eu/
Anticipating the effects of climate change on vineyards using satellite imagery
(vidéo) https://www.deepplanet.ai/blog/chteau-pape-clment-amp-deep-planet- anticipation-the-effects-of-climate- changement-dans-le-vignoble-grâce-à-l'imagerie-satellite
'Hot and stressed' grapes: Start-up helps winemakers survive climate change with AI and satellite technology
(blog) https://www.deepplanet.ai/blog/chteau-pape-clment-amp- deep-planet-anticipate-the -effets-du-changement-climatique-sur-le-vignoble-en-utilisant-l'imagerie-satellite

How satellites put better wine in your glass
(blog) https://www.sspi.org/cpages/how-satellites-put-a-better-wine-in-your-glass

The benefits of satellite imagery for precision viticulture
(blog) https://ts2.space/en/the-benefits-of-satellite-imaging-for-precision-viticulture/

How does Copernicus help facing the wine industry with climate change?
(blog) https://www.copernicus.eu/en/news/news/observer-how-does-copernicus-help-wine-industry-face-climate-change

Copernicus data supporting quality predictions: Saturnalia
(application) https://business.esa.int/projects/saturnalia
Oenoview® : satellite imagery for precision viticulture
(appli) https://www.icv.fr/viticulture-oenology-consulting/oenoview

How satellites help wineries choose new climate-friendly sites (newspaper)
https://www.washingtonpost.com/food/2023/05/11/satellites-help-wineries-climate-friendly-sites/

Remote sensing in viticulture (special issue of articles)
https://www.mdpi.com/journal/remotesensing/special_issues/viticulture

Viticultural manipulation and new technologies to address environmental challenges caused by climate change
(article) https://doi.org/10.3390/cli11040083
Viticulture and cultural landscapes: remote sensing and modeling of Earth surface processes to promote sustainable agricultural practices
(article) https://doi.org/10.1109/MetroAgriFor55389.2022.9964716

A new satellite NDVI-based sampling protocol for grape ripening monitoring.
(papier) https://doi.org/10.3390/rs12071159

Towards monitoring the water status of vines on a large scale using Sentinel-2 images
(papier) https://doi.org/10.3390/rs13091837

4.5 Vitivoltaic

Vitivoltaic consists of setting up systems to combine wine production and electricity production on the same plot. These systems are called dynamic agrivoltaics if the solar panels are mobile and unfoldable, and are controlled to optimize agricultural production. The construction of photovoltaic systems is lately an important stage in order to develop a strategic approach based on sustainability for the rational use of energy in order to increase the efficiency of all activities within a winery.


© sun'agri

Objectives:

Renewable energies constitute one of the pillars of the fight against global warming. The photovoltaic market is experiencing a strong growth rate, but the installation of power plants is subject to environmental constraints, their installation being limited to non-arable areas or integrating a mix of uses.
In order to respond to the issue of possible land use conflicts, vitivoltaic aims to develop agrivoltaic systems, which combine agricultural production/wine production and electricity production simultaneously on the same plot. The Sun'Agri research project was initiated in 2009 by a partnership between INRAE and the company Sun'R and aims to study and answer the questions raised by this cohabitation on the same plot of an agricultural activity and an energy production activity.

Applications:

Agrivoltaic systems are inspired by the principle of layered crops and agroforestry, where several species are cultivated on different levels, thus creating synergy between them. The top floor here is made up of photovoltaic panels and aims to both reduce the effects of climate change and produce electricity.
"Like a human being who takes an umbrella to protect himself when it is very hot, the vine needs protection when there are high temperatures to carry out its cycle normally» Hugues Gauthier winemaker in AOP Coteaux d'Aix en Provence and IGP Var/Mediterranean.
"These are installations on small areas (1 to 5 ha), set up during replanting. The winegrowers who contact us do so above all to find solutions to global warming. We support them technically and administratively," explains Antoine Nogier, president and founder of Sun'Agri.
"The construction of the project on site takes place over four to five months," explains Jonas Dubois, cultivation manager at Sun'Agri. "A metal frame made up of driven piles driven 2 meters is erected. The panels are installed on the North-South axis to capture the position of the sun on the East-West axis. The management is done by algorithm and takes into consideration the needs of the culture and the specific requests of the winegrower.


© INRAE

Results:

The first results collected during the 2019 campaign at the Piolenc site in the Eastern Pyrenees showed that the vines sheltered under this system resisted the intense summer heat better than the others.
Under the shade houses, irrigation requirements are reduced by 12 to 34% depending on the conditions, irrigation was triggered later, the soil water reserve is 20 millimeters higher and the cessation of growth is delayed by 10 at 15 days compared to the control vine without photovoltaic protection.
Shading also had a positive effect on berry weight, 17% higher in protected vines. Finally, it also had a beneficial effect on the organoleptic quality of the wines. The anthocyanin content is higher (+13%), as is the total acidity (+9 to +14% depending on the conditions).
"The data collected in 2020 points in the same direction. In addition, in the tests carried out at Pech Rouge where the shaded plot and the control vine were harvested on the same date, we noted a difference of 1% vol. of alcohol between the wines from shaded vines (the lowest in alcohol) and those from the control plot without shade" indicates Perrine Fortin, Head of the Agro Division at Sun'Agri.

The readings measured up to -4°C under the shutters during the summer of 2022, but -10°C on floors and surfaces in direct sunlight. We also measured +1.5°C during frost periods under covered vines. The balance of the wine is also better preserved: -1.5% alcohol, and a gain of 1% in total acidity.
The management of the infrastructure by algorithm using sensors and artificial intelligence takes into consideration the needs of the crop and the specific requests of the winegrower: "The first reason is to protect the vines. The panels therefore recede more in the spring to encourage growth and in summer they begin to do tracking (positioning the solar panels according to the best possible inclination). »
The device allows the creation of shade on the ground, thus limiting evapotranspiration, avoiding sunburn but can also protect against violent rain and hail. It was also possible to note the appearance of grass in the shaded inter-row areas and therefore consider long-term soil revitalization.
"Covering the vine allows the cycle to run normally. It's all good for her! The shaded soil remains moist and we find maturities from before climate change" reports Hugues Gauthier, a wine grower in Provence who also notes that there is no problem with the passage of machines (intervines, treatment, topping, etc.)".


Alira Winery, Constanta, Romania

Limits and questions
Fixed installation installed on agricultural land for several decades
Investment cost: between 800,000 and 1 million euros/ha for the installation. Projects can be co-financed by public and private investors.
Additional income: will vitivoltaic allow wine growers who embark on this path to generate additional income or only to benefit from a structure of protection against climatic hazards with self-consumption of electricity?
Appellation: will winegrowers who put signs on their vines lose their appellation?
Landscape impact: the impact is not negligible even if it is less than wind turbines. It seems comparable to the visual impact of an agricultural greenhouse.


© sun'agri

In the wineries sector there are more and more producers interested in applying a sustainable approach by using photovoltaic panels, such as:
- The Moldovan wine producer Purcari Wineries, listed on the Bucharest Stock Exchange, installs a photovoltaic system on the roof of the production hall of Purcari Winery, which will provide 15% of its electricity consumption. The photovoltaic station covers an area of 1,025 square meters and allows the production of 240.00 kWh of energy per year, according to the company's announcement.
- Inaugurated in 2016, Crama Marcea, is revolutionary and represents an innovation in the field of winemaking in Romania. It is the first and only completely energy independent winery. Electricity is produced by roof-mounted photovoltaic panels, while thermal energy is taken from deep within the earth, geo-thermal energy, through a heat pump.
- Alira Winery provides electricity provided by solar panels (104 kW), and air conditioning by an underground thermal field.
- E.ON Energie Romania together with Recaş Cellars have started an investment of 430,000 euro for a solar project that provide 20% of the wine producer's energy needs. The project contributes to reducing of CO2 emissions of Recaş Winery.

More informations:

Scientific articles from INRAE

https://www.inrae.fr/actualites/systemes-agrivoltaiques-conciliant-production-agricole-production-delectricite
https://www.inrae.fr/actualites/agrivoltaisme-creation-dun-pole-national-recherche-innovation-enseignement

News articles from professional medias

https://www.vitisphere.com/actualite-93764-26-projets-photovoltaiques-dans-le-vignoble-pour-sunagri.html#:~:text=Pionni%C3%A8re%20de%20l'agrivoltaïsme%2C%20la,lutter%20contre%20le%20r%C3%A9chauffement%20climatique.
https://www.vitisphere.com/actualite-100185-des-panneaux-photovoltaiques-au-dessus-des-vignes-de-bordeaux.html
https://www.vitisphere.com/actualite-98801--pour-les-vignerons-installer-des-panneaux-photovoltaiques-cest-une-bonne-affaire.html
https://www.vitisphere.com/actualite-99849-le-photovoltaique-pari-vigneron-face-aux-aleas-climatiques.html
https://www.vitisphere.com/actualite-95277--premiers-resultats-prometteurs-pour-les-vendanges-sous-persiennes-photovoltaiques.html
https://www.vitisphere.com/actualite-95401-anti-coup-de-soleil-et-antigrele-pour-cette-vigne-sous-ombriere-photovoltaique.html

Links to voltaic private companies web sites

https://sunagri.fr/
https://www.ombrea.fr/

5.1 Reduce the GHG Balance of the vineyard

Under the effect of Greenhouse Gases or GHGs (carbon dioxide, methane, nitrous oxide, halocarbons, fluorinated hydrocarbons and tropospheric ozone), the earth's atmosphere behaves like the glass of a greenhouse, letting in a large part of solar radiation, but retaining the re-emitted infrared radiation.
The increase in GHGs "thickens" the glass of the greenhouse and is therefore at the origin of the increase in temperatures, and therefore global warming. There is an established correlation between the evolution of temperature and the concentration of CO2 in the atmosphere.
According to experts, in order not to reach a 2°C increase with devastating consequences, it is absolutely necessary to stabilize the CO2 concentration well below 550 ppm.
Like all human activities, the activity of the wine industry contributes to the increase in GHG concentrations in the atmosphere. The carbon footprint of the French Vine-Wine sector is approximated at 6.5 million tonnes of CO2 per year. The Environment and Energy Management Agency (ADEME), estimates in France, between 1 and 1.5 kg eq. CO2 the emission produced by a 75 cl glass bottle. This value increases when it comes to great wines which are packaged in heavier bottles. Capping, as well as over-capping, are also elements that can modify these emissions. Indeed, wine packaging is by far the heaviest item in terms of GHG emissions, representing 40 to 50% of the total. Grape production, from planting to harvest, represents around 20% of the total.
For example, the carbon footprint of the Bordeaux sector is estimated at 768,000 T CO2 eq/year, which is equivalent to the carbon footprint of more than 70,000 French people, or 146 kg eq. CO2/hl of wine produced.
A French consumer drinks on average 44 liters of wine each year, which is equivalent to 58 75 cl bottles, representing a GHG emission of around 64 kg eq. CO2. Furthermore, approximately 38,280 liters of water are required to produce this quantity of wine.

Objectives:

At the French level, the National Low-Carbon Strategy aims to achieve carbon neutrality by 2050, -46% greenhouse gas emissions compared to 2015.

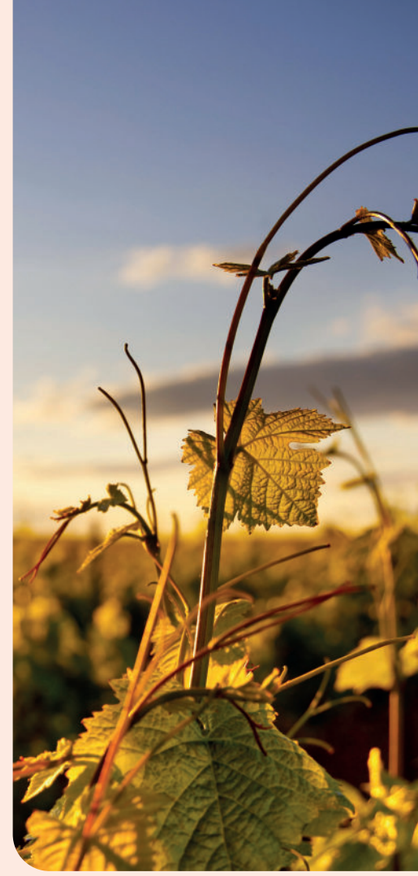
To achieve this objective, it is necessary to have a "Low Carbon" or "Low GES" vineyard. In fact, according to measurements, between 20 and 33% of greenhouse gas emissions from the global wine industry come from work in the vineyard.
Vine sector of a wine farm, according to a study carried out by the Gironde Chamber of Agriculture, represents 92% of GHGs from wine production, excluding packaging.

The reasons for this are numerous.
We can cite, among other things, the combustion of fuel oil, which powers tractors and grape harvesting machines. According to a study carried out by the Inter-professional Champagne Wine Committee (CIVC), fuel oil for the fueling of wine tractors represents 11 to 21% of the total contribution depending on the area.
The use of synthetic fertilizers and phytosanitary products is also a high-impact item. In addition to their production, transport and energy consumption, their spreading is also a significant source of GHG release into the atmosphere.
The margins for progress on the Vine station are therefore significant.
In this context, the tool developed by the IFV GES&Vit for calculating the carbon footprint of wine farms makes it possible to carry out the diagnosis of Greenhouse Gas (GHG) emissions from the wine workshop until the grape harvest. (scope which constitutes approximately 20% of the sector's GHG emissions), to compare different driving modes, to carry out simulations of changes in practices, and to evaluate an action plan to reduce these emissions.

Applications:

There are numerous ways to go towards a "Low Carbon" or "Low GES" vineyard and they are sometimes quite simple to set up.

- **Reduce tractor passages** by combining interventions and tools "For example, we can easily imagine a single passage for trimming and mowing the cover. "The combination of tools alone allows 40% savings in fuel oil," estimates Léna Plusquellec, advisor to the Bordeaux-Gironde Chamber of Agriculture. It is also advisable to get tractor drivers to adopt eco-driving and for better efficiency and lower consumption, to put tractors and sprayers on the test bench or to invest in breakthrough solutions such as electric tractors and autonomous robots. (see files)
- **Offset emissions** through agroecological infrastructure: In 2021, the 12 farms studied by the Gironde Chamber of Agriculture would have overall offset 74 to 100% of their GHG emissions through agro-ecological infrastructure, such as hedges or large areas. covered with grass. (see viti-forestry sheet)
- **Reduce the use of mineral fertilizers** and synthetic phytosanitary products, by replacing them with organic solutions (manure) (see vitigrazing sheet) or by reducing doses (of nitrogen in particular).
- **Lighten treatment programs** and thus use fewer synthetic phytosanitary products whose production is far from neutral in terms of greenhouse gas production, fewer passages and therefore less fuel oil Replace synthetic phytosanitary products with organic solutions. (see sheets 7) (see vitigrazing sheet)
- **Use plant cover** between rows and under the row (see sheets above)
- **The reduction of GHG emissions must also be reasoned from planting** by the choice of grape varieties resistant to fungal or/and local diseases (see sheets above), long rows, lower planting densities, favoring the use of stakes in wood, rather than galvanized steel stakes…



Results:

The expected result of having a "Low Carbon" or "Low GHG" vineyard is a reduction in the GHG footprint of the vine-wine sector. At the French level, the National Low-Carbon Strategy aims to achieve carbon neutrality by 2050, -46% greenhouse gas emissions compared to 2015.

To achieve this objective, having a "Low Carbon" or "Low GHG" vineyard is not enough. We must also act on the posts downstream of the vines.
A study carried out by the Inter-professional Champagne Wine Committee (CIVC) showed that the CO2 taken by the vines for photosynthesis was balanced by the CO2 released by respiration, must fermentation, burning or degradation on the ground after crushing. pruning timber as well as burning the frames after uprooting.

Finally there is the International Wineries for Climate Action (IWCA), a collaborative working group of environmentally committed wineries who are taking a science-based approach to reducing carbon emissions throughout the wine industry. The goal is to share best practices that mitigate the impacts of climate change in vineyard and winery operations so that we can act collectively to decarbonize the global wine industry, applying direct solutions that avoid the purchase of credits carbon offset. Source : https://www.iwcawine.org/

More informations:

https://www.ecologie.gouv.fr/strategie-nationale-bas-carbone-snbc
https://www.oiv.int/public/medias/4523/publication-bilan-ges-fr.pdf
https://agribalyse.ademe.fr/app/aliments/5214#Vin_rouge
https://www.vignevin.com/publications/fiches-pratiques/bilan-carbone-en-viticulture/
https://www.vignevin.com/article/outil-devaluation-de-lempreinte-carbone-des-exploitations/
https://www.bordeaux.com/fr/Vignoble-engage/Nos-engagements/Impact-environnemental
https://www.vignevin-occitanie.com/fiches-pratiques/bilan-carbone-en-viticulture/
https://www.champagne.fr/fr/les-engagements-dans-le-champagne/la-filiere-champagne-s-engage/empreinte-carbone-champagne
https://www.vitisphere.com/actualite-98994-1er-outil-devaluation-de-lempreinte-carbone-des-vignobles.html
https://www.vitisphere.com/actualite-98141-des-pistes-pour-ameliorer-le-bilan-carbone-vigneron.html
https://www.mon-viti.com/articles/viticulture/en-nouvelle-zelande-le-domaine-yealands-estate-est-exemplaire-dans-sa-demarche

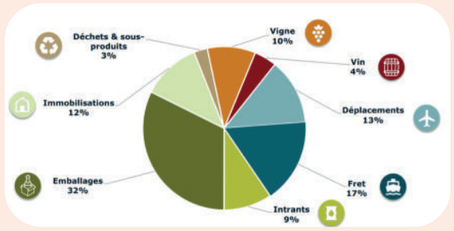
5.2 Reduce the GHG Balance of the wine

Under the effect of Greenhouse Gases or GHGs (carbon dioxide, methane, nitrous oxide, halocarbons, fluorinated hydrocarbons and tropospheric ozone), the earth's atmosphere behaves like the glass of a greenhouse, letting in a large part of solar radiation, but retaining the re-emitted infrared radiation.
The increase in GHGs "thickens" the glass of the greenhouse and is therefore at the origin of the increase in temperatures, and therefore global warming. There is an established correlation between the evolution of temperature and the concentration of CO2 in the atmosphere.
According to experts, in order not to reach an increase of 2°C with devastating consequences, it is absolutely necessary to stabilize the CO2 concentration well below 550 ppm.
Like all human activities, the activity of the wine industry contributes to the increase in GHG concentrations in the atmosphere. The carbon footprint of the French Vine-Wine sector is approximated at 6.5 million tonnes of CO2 per year. The Environment and Energy Management Agency (ADEME), estimates in France, between 1 and 1.5 kg eq. CO2 the emission produced by a 75 cl glass bottle. This value increases when it comes to great wines which are packaged in heavier bottles. Capping, as well as over-capping, are also elements that can modify these emissions. Indeed, wine packaging is by far the heaviest item in terms of GHG emissions, representing 40 to 50% of the total. Grape production, from planting to harvest, represents around 20% of the total.
For example, the carbon footprint of the Bordeaux sector is estimated at 768,000 T CO2 eq/year, which is equivalent to the carbon footprint of more than 70,000 French people, or 146 kg eq. CO2/hl of wine produced.
A French consumer drinks on average 44 liters of wine each year, which is equivalent to 58 75 cl bottles, representing a GHG emission of around 64 kg eq. CO2. Furthermore, approximately 38,280 liters of water are required to produce this quantity of wine.

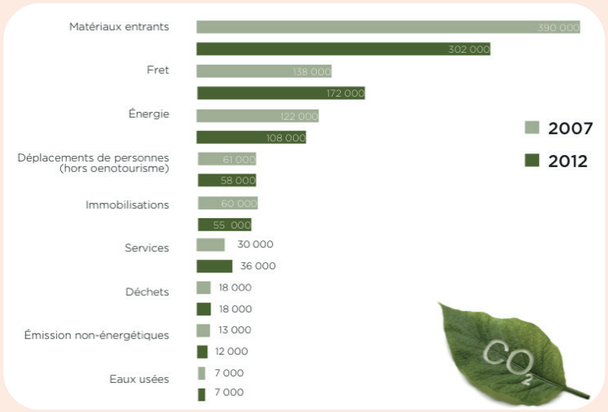
Objectives:

At the French level, the National Low-Carbon Strategy aims to achieve carbon neutrality by 2050,-46% greenhouse gas emissions compared to 2015.
To achieve a bottle of wine with a "Low carbon/GHG" or even CO2/GHG neutral footprint, it is also necessary to act on the downstream stations in the vineyard. In fact, out of 1.1kg of CO2 emitted by a bottle of wine, the packaging of the wine can alone represent up to 50% of the total emissions. It is therefore important to know the impact of each position and input.

Principaux postes du bilan carbone de la filière Vin de Champagne
Source CIVC 2018



Principaux postes du bilan carbone de la filière Vin de Bordeaux
Source CIVB AGENCE FLEURIE



Applications:

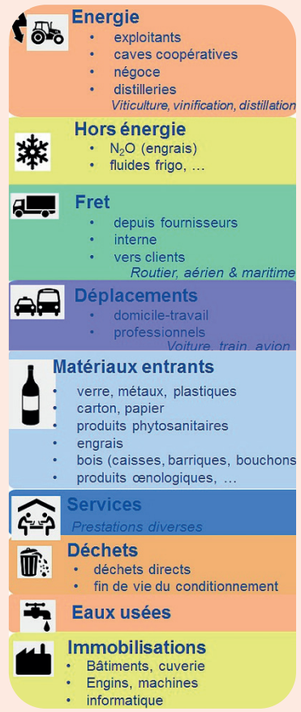
Some items have no or almost no impact, given the quantities used. These are:
• CO2 excluding energy, used for inerting musts
• The use of plastic including stretch films
• Yeasts and oenological products of mineral or vegetable origin
• Cork for stoppers due to low weight and low emission factor
• Printed paper for labels and back labels
• Direct waste
• Wastewater

Conversely, certain positions have a much heavier environmental impact:
• The use of wine bottles for packaging (from 17 to 27% of the total contribution)
• The use of printed cardboard (up to 13%)
• Road freight to customers (up to 20% contribution in certain areas)
• The eco-design and insulation of buildings have a major influence on the energy required for their air conditioning (see factsheets)
The options for moving towards a "Low Carbon" or "Low GES" wine are numerous and sometimes quite simple to implement.

Several reduction paths can be put forward. Among those:

• Renewable energies, for example the installation of solar panels on the cellars.
• Sorting and recycling of waste, through the valorization of vine stocks, the collection and valorization of EVPOH (Empty packaging of oenological and hygiene products)... and the "circular economy" which treats and valorizes this waste in associated processing channels.
• The use of collective equipment use cooperatives to consume less diesel and benefit from various equipment or the sharing of experience between members.
• Reducing CO2 emissions through its capture and recovery during fermentation. This constitutes a significant environmental benefit, with nearly 10kg of CO2 avoided in the atmosphere per hectoliter of wine produced. To achieve this, CO2 capture networks are installed on each tank. These reactors transform CO2 into bicarbonate which is then filtered, dried and reusable in different industrial branches (cosmetics, pharmaceuticals, etc.).
• The use of lighter glass bottles but with the same conservation quality. The glass bottle actually represents between 15 and 20% of greenhouse gas emissions. It requires significant energy to produce and transport it. It is possible to think about replacing glass with other materials. The choice of recyclable materials for packaging and promoting cork closure, a natural material which contributes to the maintenance of a forest, a real carbon sink…
• The use of collective transportation or bicycle instead of the car or the plane for home-to-work and professional trips, replacing the road transport of goods with piggybacking for example, limiting emissions linked to long transport of goods to abroad, use electric vehicles, biofuels as an alternative to the consumption of fossil fuels, etc.
Or more technical measures such as recovery and heat recovery in a classic wood chip boiler of pruned wood and frames if they replace the consumption of fuel oil or gas or the use of nitrogen

Principaux postes du bilan carbone de la filière Vin
Source CIVB AGENCE FLEURIE

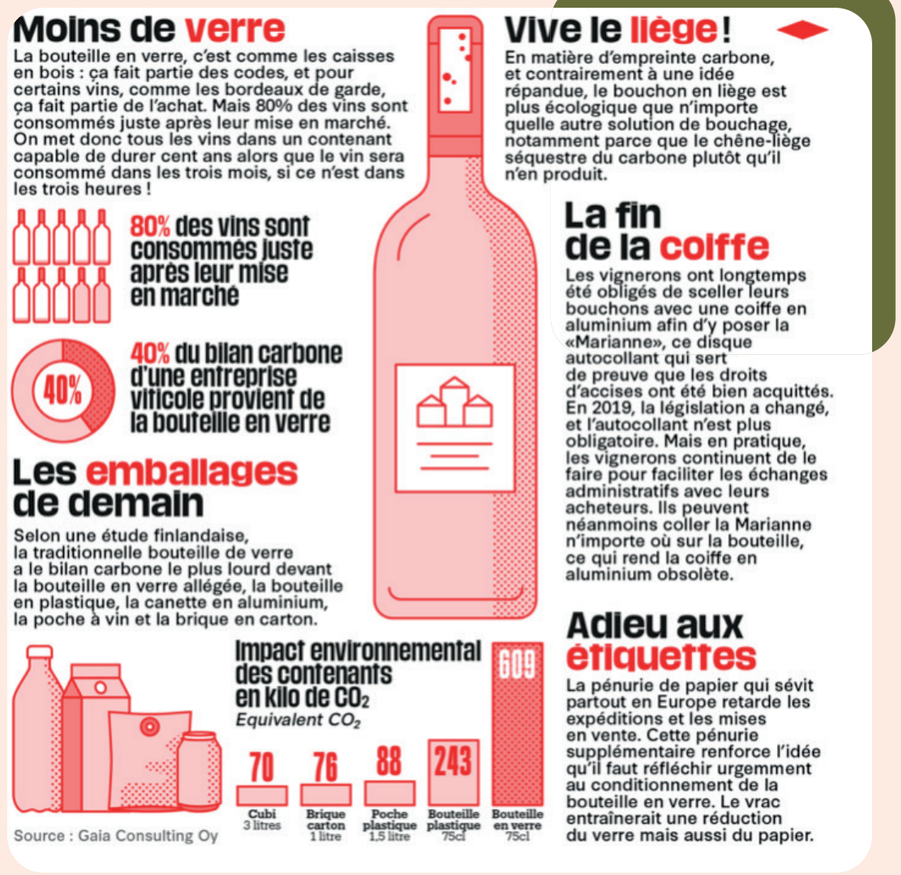


Results:

The expected result of having a "Low Carbon" or "Low GHG" vineyard is a reduction in the GHG footprint of the vine-wine sector. At the French level, the National Low-Carbon Strategy aims to achieve carbon neutrality by 2050, i.e. -46% greenhouse gas emissions compared to 2015. Some vineyards have set deadlines even more ambitious, like Burgundy which is aiming for carbon neutrality by 2035.

Finally there is the International Wineries for Climate Action (IWCA), a collaborative working group of environmentally committed wineries who are taking a science-based approach to reducing carbon emissions throughout the wine industry. The goal is to share best practices that mitigate the impacts of climate change in vineyard and winery operations so that we can act collectively to decarbonize the global wine industry, applying direct solutions that avoid the purchase of credits carbon offset.
Source : https://www.iwcawine.org/

Infographie réalisée par l'ADEME, Alko, BIVB, CIVB, CIVC, IFV, Nomacorc, OIV et Verallia sur l'empreinte carbone de la filière vin.



More informations:

French Official informations and documentation
https://www.ecologie.gouv.fr/strategie-nationale-bas-carbone-snbc
https://www.oiv.int/public/medias/4523/publication-bilan-ges-fr.pdf
https://agribalyse.ademe.fr/app/aliments/5214#Vin_rouge

Scientific articles from IFV (Institut Français Vigne et du Vin)
https://www.vignevin.com/publications/fiches-pratiques/bilan-carbone-en-viticulture/
https://www.vignevin.com/article/outil-devaluation-de-lempreinte-carbone-des-exploitations/
https://www.vignevin-occitanie.com/fiches-pratiques/bilan-carbone-en-viticulture/

Professionnal documentation from Bordeaux and Champagne collective comitees
https://www.bordeaux.com/fr/Vignoble-engage/Nos-engagements/Impact-environnemental
https://www.champagne.fr/fr/les-engagements-dans-le-champagne/la-filiere-champagne-s-engage/empreinte-carbone-champagne

https://www.vitisphere.com/actualite-98994-1er-outil-devaluation-de-lempreinte-carbone-des-vignobles.html
https://www.vitisphere.com/actualite-98141-des-pistes-pour-ameliorer-le-bilan-carbone-vigneron.html
https://www.mon-viti.com/articles/viticulture/en-nouvelle-zelande-le-domaine-yealands-estate-est-exemplaire-dans-sa-demarche