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Water as a critical issue for viticulture in southern Europe: sustainability vs competiveness

Sourced from the research article "Modern viticulture in southern Europe: vulnerabilities and strategies for adaptation to water scarcity" (Agricultural Water Management, 2016)[1].

>>> Water is a vulnerable resource in the Mediterranean region, but irrigation demands have been increasing to mitigate effects of environmental stress. Sustainable wine production involves the precise use of water in the vineyard and winery. Improved knowledge on grapevine ecophysiology and genetics, the use of sensors for soil and canopy monitoring, plant phenotyping and improved crop management can help save water. In the winery, best management practices and improved water metrics will promote water savings and decrease wastewater production. <<<

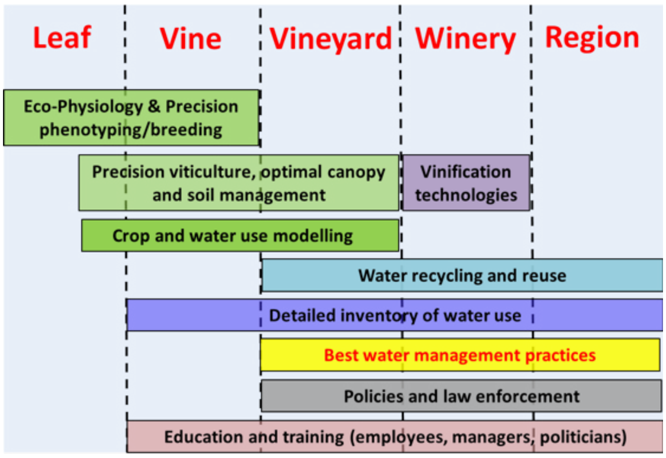

Figure 1. Water management from leaf/plant to landscape/regional scales and from agronomical technology to governance.

Integrative water management. From leaf/plant to the winery and region

Water is a highly vulnerable resource in Mediterranean regions and climate scenarios for South Mediterranean Europe are not favourable. According to the OIV, the EU-28 leads global wine production and exports (50 % of global vine-growing area and 60 % of global volume). Spain has the world's largest vineyard area (about 950 Kha) and the irrigated area has increased rapidly in recent years (from 36 % in 2014 to almost 40 % in 2019). Portugal, is the fifth largest wine producer in the EU, with a production volume of 6,4 Mhl and a cultivated area of 190 Kha, 10-15 % of which being now irrigated. Specific regional legislation imposes restrictions on water use, but irrigation has expanded in Southern Europe (e.g. Spain, Portugal, France) to mitigate climate risks and assure yields and quality. Mediterranean viticulture and wine industry must adopt more integrative approaches (from vine's eco-physiology to landscape conservation and consumer trends) to be more sustainable and competitive. More efficient water use depends on improved knowledge of water management from leaf/plant to landscape/regional scales and from agronomical technology to governance (Fig. 1 and Fig. 2).

Understanding plant-environment relations

Increased tolerance/resistance to drought and heat stress depends on the interaction of multiple traits/mechanisms (genetic, biophysical, physiological, etc.) occurring at different time scales. Short-term responses include appropriate control of stomatal conductance, drought signaling (e.g. via abscisic acid) and gene responses, whereas long-term responses relate to root/shoot balance, metabolic acclimation (e.g. respiration), berry quality traits and yield. Therefore, selection of grapevine genotypes for Mediterranean conditions must take into account a compromise between high water use efficiency (WUE)[2] and leaf cooling, together with high hydraulic conductivity and adaptation to poor soils. WUE is a complex multi-trait phenotype related to stomatal control but also with leaf structure, leaf biochemistry and leaf diffusive properties, hydraulics and hormones[2,3]. Root distribution and depth depends on rootstock/cultivar combination and soil characteristics. The roots' capacity to adjust water supply to shoot transpiration demand is crucial for increasing tolerance to drought and embolism. Stress recovery should be fast and efficient to improve adaptation to stress. Indeed, the vine's carbon balance during water stress and recovery cycles depends on the speed and degree of photosynthetic decline/recovery and on the restorative capacity of xylem function[3]. Genotypes with carbon efficient plant/root systems would show a competitive advantage in dry climates and shallow soils by a more effective exploitation of soil volume using less carbon reserves. Large scale grapevine phenotyping is needed to characterize and select novel and/or uncharacterized genotypes. In parallel, molecular approaches will help to assess the role of specific genes influencing plant traits related to water and thermal relations (stomatal regulation, hydraulics, hormonal signalling)[4,5].

Best practices in the vineyard and winery and improved metrics

Best practices in the vineyard and winery are crucial to save water (Table 1). Irrigation below evapotranspiration losses (deficit irrigation) helps to save water but relies on robust assessment of soil/plant water status and on knowledge of genotype characteristics in order to tune irrigation as function of the varieties and/or farm's irrigation sectors. Assessment of soil spatial heterogeneity (e.g. by soil profiles, electrical conductivity maps) is crucial for efficient fertilization and irrigation. Increasingly cheap yet robust sensors are being tested and used in precision viticulture. Improving water performance metrics requires precise quantification of water inputs and outputs in the vineyard and winery (Table 1). However, the high number of indices used to characterize "sustainability" makes it difficult to compare companies in different countries regarding the efficiency in the use of inputs (e.g. water). Benchmarking can also help to improve farm and winery efficiency by setting more objective standards for environmental performance. In parallel, soil conservation is another critical issue for Mediterranean viticulture.

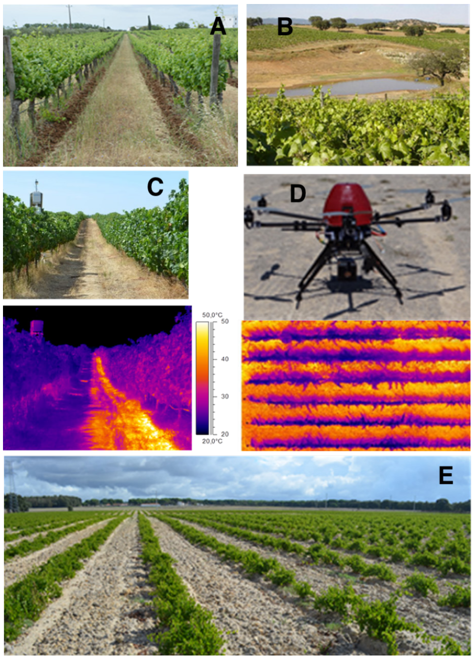

Figure 2. A) Soil management strategy in Alentejo (South Portugal) with row mobilization to avoid the use of herbicides (M. Costa); B) Small reservoir to store rainfall water and promote water infiltration, at Alentejo (South Portugal) (C. Lopes); C) Soil and vine's temperature measured with thermography in experimental vineyards in Alentejo (Portugal) (Flir B20, Flir Systems, USA, mounted on a tripod) (M. Costa & R. Egipto) and D) in Balearic Islands (Spain) (Gobi384 (Xenics, Belgium) mounted on a drone) providing thermal images on the temperature difference between soil and vines as well as temperature gradients from soil to the top of the canopy (J. Gago, J. Escalona, H. Medrano); E) Future field trial for grapevine selection and to study grapevine clones of Portuguese varieties (PORVID experimental fields, Pegões, Portugal) (M. Costa).

Minimizing herbicide use and increasing soil organic matter (O.M.) are approaches to promote sustainable management. Cover crops benefit soil O.M. and prevent erosion, but they compete for water under dry conditions, which demands precise irrigation strategies.

■ Certification and environmental legislation

Water metrics and certification for environmental sustainability are increasingly important issues for the

Table 1. Non-exhaustive list of water saving, best water management practices and water conservation strategies to be implemented at different scales, the vineyard, the winery and the region.

WATER SAVING & CONSERVATION STRATEGIES	PHYSICAL SITE		
	Vineyard	Winery	Region
Install flow meters on wells/pumps / down individual rows to evaluate water use (in the vineyard and winery); Record data regularly, set a standard value and search for discrepancies.	X	X	X
Guarantee maintenance of the irrigation system (filters, flow meters, gutters, lines) by periodic checking pipe connections and taps for leaks.	X		X
Deficit irrigation, well adapted variety/rootstock, proper soil characterization (depth, profile, water holding capacity, fertility).	X		X
Precise crop/soil monitoring (e.g. soil and plant water status, vineyard's evapotranspiration).	X		
Implement "Good Environmental Management Practices" for water, biocide and fertilizer management, soil management and machinery and vehicle management.	X		X
Use pond processed water for vineyard and/or landscaping irrigation; Use drought tolerant species for landscape purposes.	X		X
Save water in the winery/cellar by using saving alternatives (e.g. use ozone system for winery equipment cleaning/sanitation), monitor water use in washing/soaking of barrels, install flow meters to assess water use in cleaning operations along vinification process.		X	
Improve winery waste management/treatment by adapting and implementing more cost-effective treatment technologies for effluents and solid residues.		X	X
Promote staff training (vineyard management, irrigation water use, winery cleaning, environmental risk assessment, general management).	X	X	X
Optimize technical assistance and support to wine producers to meet environmental regulations, improve their image near consumers and their sales.	X	X	X
Water use benchmarking to set reference values. Develop "water performance" indicators for the vineyard and winery. Set targets and implement auditing and reporting.	X	X	X
Quantify market benefits by adopting environmental management systems and by promoting environmental credentials to guarantee a good environmental management.	X	X	X
Implement LEAN procedures in viticulture and oenology & circularity approaches.	X	X	X

wine industry and governmental officials. Water footprint (WFP) emerged as a basic, theoretical, consumption-based indicator of water use and it looks at both direct and indirect water use by a consumer or producer[6]. However, generalized values of WFP for a certain commodity can hide differences between regions and mislead consumers and authorities. Life Cycle Assessment (LCA) is another tool that can be used to assess environmental impacts of wine production[7]. Viticulture, especially under irrigated conditions, can have a major water footprint but winery wastewaters have also high pollutant impact if mismanaged. Robust WFP and LCA analysis depends on reliable water statistics but the availability of data on water use, water abstraction, water quality remains critical for proper quantification and governance of water flows at farm, the winery and the region. In 2007, the EU Commission established a strategy to face water scarcity based on five pillars: 1) put the right price tag on water, 2) promote more efficient water related technologies and practices, 3) improve drought risk management, 4) enhance water-saving culture and 5) improve knowledge and statistical data collection. However, down-scaling such policies to national and regional levels is a difficult practical task.

■ Final remarks

Modern viticulture must integrate best practices for more sustainable water use and nature conservation. More reliable statistics and standards are crucial to support water metrics and water management policies to minimize the environmental impact of the wine industry. Precise vine and soil management supported by larger, cheaper yet robust sensing technologies are envisaged to assist decision support systems for vineyards and wineries. Ultimately, improved knowledge exchange and demonstration (e.g. peer to peer) is a crucial tool for innovation and implementation of best practices in global agriculture (see https://nefertiti-h2020.eu). This can be especially relevant for smaller companies (vineyards, wineries, enotourism)[8] in countries where public extension services are strongly reduced such as in Portugal. ■

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