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The challenging issue of climate change for sustainable grape and wine production

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The links between grape production, wine quality, climatic conditions and geographical origins are tied, making ongoing climate change a quite challenging issue for this economical sector. How climatic conditions will be affected locally, how local climate will interact with topography, resulting in a high climatic variability at vineyard scale, how vine performances, berry composition and wine quality will be modifed, what can be done to adapt vine growing and wine making practices to these new conditions ? Here are the numerous questions the wine industry has to face in the following decades. In this context, it is obvious that this issue will require the development of close collaboration between actors, including producers and wine makers, extension services, marketing, policy makers and scientists. In the scientific community itself, addressing this issue requires multidisciplinary studies and new approaches for performing science.

Since 2012, the LACCAVE project, developed in France to study the long term impacts and define adaptation strategies for viticulture and oenology, was based on this vision. It gathers, in the frame of the Metaprogramme ACCAF (Adaptation to climate change of Agriculture and Forestry) led by the French Institut National de Recherche Agraonomique (INRA), scientists from 23 French laboratories dealing with different aspects of climate change: climatology, physiology, pathology, agronomy, oenology, genetics, economics and, social sciences. After 4 years working together, they have developed a shared vision about climate change and its impacts on grape and wine production. They also delivered several important results to the industry in order to define adaptive strategies. ClimWine2016, the final international symposium of Laccave project was held in the same spirit. Scientists from 20 different countries came to Bordeaux from April 11 to 13 2016 to present their work related to climate modeling, impacts on vines and wines, possible adaptations at different scales, and socio-economic outputs. This symposium was also an important opportunity not only to exchange between among themselves researchers, but alsoand with some representatives of the industry.

General trends of already observed and expected climate change and their impacts on grape growing show that the planet has is warmer than at any time in our recorded past and extremes in temperature and precipitation have increased (Jones, 2017, in this issue). Most vineyards throughout the world face the same situation and some vineyards from low latitudes as Portugal may be endangered in the following decades (Fraga et *al.*, 2017). Climatic modelling at the appropriate scale is crucial to simulate future conditions (Quenol et *al.* 2017). In particular, high resolution atmospheric modelling provides useful information to understand climate variability at high spatial and temporal scale and to allow better decision-making for adaptation at the terroir level (Sturman et *al.*, 2017). Water availability will become a major concern. Considering that simulations for precipitations are characterized by a large uncertainty, it is determinant to analyze the evaporative demand of the atmosphere which has so far shown different evolutions according to the considered vineyard. Wind appears to be a key component of these variations (Schultz, 2017). Impacts of climate change on grapevine physiology are numerous. Phenology, driven mainly by temperature, is the first component to be affected and is a key parameter for varietal adaption (Garcia de Cortazar-Atauri et *al.*, 2017). However temperature effects are complex and carbon balance at the whole plant level should be considered (Torregrosa et *al.*, 2017). Interactions with high CO_2 have to be taken into account and impacts of future climatic conditions may be larger than might be predicted from experiments examining factors one by one (Edwards et *al.*, 2017). Fruit composition, especially aroma compounds, is a real matter of concern. These molecules contribute to the typical identity of wines and are highly variable according to climatic conditions and growing practices (Pons et *al.*, 2017). The evolution of pest and diseases is another important issue which is much more difficult to document.

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Worldwide repartition of diseases does not really help to get clear idea of risk occurrence in the future (Bois et *al.*, 2017). To face these new conditions and ensure the sustainability of the industry, adaption should be considered at every level of the production and value chains. At short term scale, winemaking and oenological practices may contribute to process grapes with higher sugar content and lower acidity contents (Dequin et *al.*, 2017). At longer time scale, site selection, management practices and plant material selection present a high potential to face adapt to the new climatic conditions (van Leeuwen and Destrac, 2017). Looking at the past to understand the future may be very informative and some traditional technics abandoned recently may have a high adaptive potential (Santesteban et *al.*, 2017). A major challenge will be to adapt plant material to these new conditions because adaption is a very complex trait. New approaches, as ecophysiological modelling, should be developed encouraged (Vivin et *al.*, 2017). For example, these approaches appear to be very promising to develop new varieties and rootstocks better adapted to drought (Simmoneau et *al.*, 2017).

This special issue of OenoOne, which includes some of the key contributions to ClimWine2016 symposium, provides a large overview of the most recent knowledge related to the challenge of facing climate change. It is therefore a unique document to support our global thinking to maintain the performances of the wine industry in the future. The ClimWine2016 convenors deeply thank OenoOne for this contributionthe possibility to make these articles easily accessible

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