The challenges and perspectives for Viticulture to improve sustainability in the context of climate change

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Abstract

a. Key factors in climate change

Temperature development on earth has always been strongly coupled to the CO_2 concentration of the atmosphere (greenhouse effect). This concentration has remained nearly stable around 270ppm for five centuries with maximum fluctuations between about 180ppm and 300ppm for the last 420.000 years. Since pre-industrial times, earth has experienced an increase in atmospheric CO_2 concentration of almost 50% to current levels of about 400ppm. Other "greenhouse" gases such as nitrous oxide, methane, Halocarbons and even tropospheric ozone have so far contributed an additional 70-90ppm CO_2 equivalent, raising the "active gas mix" in the atmosphere to about 470-490ppm CO_2 equivalents. With continued further increasing emission rates, CO_2 equivalents will about double by the third quarter of this century with uncertainties being related to the emissions in developing and industrialized countries, the effectiveness of control measures and the buffer capacity of the vegetation on earth and especially of the oceans. In any rate, a substantially influence on agricultural and natural ecosystems is expected for many years to come.

b. Regional trends in some grape growing areas

According to the Intergovernmental panel on climate change (IPCC 2014), global warmingwill increase air temperature in Western and Central Europe between 2.5 and >5 °C by the end of this century. A survey across many viticultural areas in the world and across a large transect of latitudes confirms this trend.

c. The water issue

Water will be one of the most important issues for a sustainable development of mankind under climate change since agriculture the most important user. The average of all applied climate models in the IPCC 2014 predict an increase in precipitation rates during winter as a result of the temperature-driven increase in the velocity of the hydrological cycle over Europe, with a decrease in summer for most areas. Higher temperatures will cause higher rates of evaporation, both from soil and from plants and this may increase the risk in terms of more frequent and more severe droughts with possible adverse effects on yield and quality. However, many observations across the globe shows no changes in evaporation rate despite increasing temperatures which seems to be related to an unexplained decrease in wind velocity. The IPPC 2014 and several detailed studies also predict a strong increase in the variability of temperature scenarios, which will be spatially and temporarily very heterogeneous across Europe. Since temperature variability entrains variability in precipitation events, it is likely that different wine growing regions in Europe will experience very different conditions according to their geographical location but also depending on the year and time during the season. The vintages 2014-2017 were/are excellent examples for this trend. One of the practical consequences will be a substantial increase in potential erosion and the need to develop suitable answers to this, especially in sloped areas.

d. Soils, the unknown climate factor

The so-called Potsdam time series of soil temperature has shown, that since 1889, the annual soil temperature has significantly increased down to a depth of 12m! Temperature increase in 1m depth, where most of the grapevine roots are located has increased to 2.6-3.2 °C between May and August as compared to the beginning of measurements. These changes are much larger than changes in air temperature and have profound effects on organic matter decay and thus the release of nitrogen, which may have a substantial effect on climate gas emission rates from the soil but also direct effects on mineral uptake and Botrytis development, for example. Soil temperature has also been shown to affect the population of fungi and bacteria on the fruit and in the juice, factors which have recently been described as important aspects in "microbial terroir".

e. Biodiversity and genetics

Losses in plant and animal biodiversity are severe problems which may be accelerated by climate change. The varietal spectrum globally used in Viticulture both for scion but also for rootstocks is rather small, despite a substantial gene pool. The public discussion on the use of pesticides, fungicides and herbicides in agriculture and specifically in Viticulture will force the industry to come up with "some answers". The current array of disease tolerant varieties with good quality traits is largely not accepted by the wine industry, partly because of the consumer trend to buy "classic varietals". However, the use of new genetic tools to develop disease tolerant varieties in the future may open up new possibilities. Additionally, the selection of specific clones from existing classic varieties exhibiting certain features helpful in the struggle for adaptation to climate change (growth habit, fruit structure) will be an accepted tool to improve sustainability. For this to be achieved genetic biodiversity is needed.

f. **Technology and conservation**

Technological advancements will be the key in preserving our viticultural environments and landscapes. For example, new developments in satellite guided working platforms, physical, thus non-chemical, treatment of diseases and new applications of drones will contribute to the conservation of Viticulture in "difficult terroir", as for example steep slope areas.