Expo Melilla 2023

What grapes and wines to expect with the drought?

¿Qué uvas y vinos esperar con la sequía?

Que uvas e vinhos esperar com a seca?

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1. Climate context

Uruguay is a country characterized by its climate variability. It is clear from the information provided that Uruguay's vineyard farm system is significantly impacted by climate variability, particularly extreme climate events, such as droughts and heatwaves. In recent years, several droughts have affected crop systems due to La Niña impact on the region, with the lack of water in soils and water sources becoming vulnerable to agricultural production systems. That is the main reason why up to January 2023 Uruguay was declared under agricultural emergency. The average rainfall in the last 25 years in Canelones department (southern Uruguay) was 87 mm per month (from 1998 to 2023)[(1)]. Still, in the last three years (2020 to 2023), the

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monthly rainfall decreased to 64 mm per month, representing a 26% decrease in the water supply. During the summer of 2023, the drought was compounded by a heat wave. While the low rainfall cannot be attributed to climate change, higher temperatures in the region are attributed to climate change, impacting a decrease in water availability[2]. This means that climate change is probably reducing water availability, thus increasing agricultural drought and exacerbating the impacts of the drought on agriculture by putting heat stress in addition to water stress on crops[2].

The accumulated drought and heatwave conditions could reduce yield, reduce canopy development, and alter the grape composition and typicity for grapevines, thus impacting wine characteristics. This indicates that viticulturists, consultants, and oenologists in Uruguay must deal with the consequences of climate variability, including extreme climate events, to maintain and improve their vineyard farm system's productivity and sustainability.

2. Grapevine characteristics and its responses to drought and elevated temperatures

Grapevines are typically considered to be Mediterranean plants with relatively lower water requirements compared to other crops. The water requirements of grapevines during the growing season (September to March in Uruguay) can range from 500 to 800 mm, as reported by Williams and Matthews[3], or 350 to 600 mm, as reported by other authors, and it's influenced by several factors such as climate, soil type, and vine age. The water requirement is higher during the growing season, typically from bud break to veraison, with a peak water use rate occurring during the rapid shoot and leaf growth period. However, drought and high temperatures during the growing season can significantly impact the grapevine's reproductive and vegetative development. The impacts of these climate conditions are the following:

Yield reduction

Insufficient water availability during the grapevine's early growth stages, from bud break to fruit set, can significantly limit yields due to several factors. Firstly, it can lead to a decrease in cell division, thus reducing yield potential. Secondly, it can reduce fruit set, resulting in a lower number of berries per bunch and affecting yield components. Lastly, it can cause berry shrivelling and dehydration, resulting in reduced berry size. According to Xiao and others[4], this phenomenon occurs due to an imbalance between phloem influx to the berry, water backflow to the vine, and berry transpiration. The shrivelling process can also trigger cellular death, which alters compound dynamics during ripening. Additionally, a severe drought during flowering can impact bud fertility for the following year's yield due to decreased available carbohydrates needed during induction[5].

Reduction of canopy development

Drought and elevated temperatures can both have a negative impact on the development of grapevine canopies. Lack of water availability can limit photosynthesis, reducing the production of assimilates required for plant growth and development. This leads to a decrease in leaf area and overall canopy size. Additionally, high temperatures can cause heat stress in plants, leading to decreased leaf expansion, stomatal closure, and reduced photosynthesis. This decreases the size and density of leaves, leading to decreased canopy development. Overall, both drought and elevated temperatures can significantly impact the growth and development of grapevine canopies[6].

Alteration of berry composition and typicity

If drought and heat waves occur during the ripening period, the berry tends to become more concentrated due to a reduction in water uptake, resulting in a decrease in berry size and an increase in sugar and phenolic compounds concentration. However, this increase in sugar concentration may not be proportional to the increase in phenolic compounds, which can result in a decoupling effect between sugar and phenols

accumulation. Sadras[7] has researched the decoupling effect on sugar and phenols accumulation. He has found that under water-deficit conditions, there is a decrease in photosynthesis and transpiration rates, leading to a decrease in sugar accumulation and an increase in berry acidity. Additionally, water-deficit conditions can decrease anthocyanin and tannin accumulation, resulting in changes in the color and flavor profile of the grapes and wine. When heat waves occur, they can exacerbate the effects of water deficit, leading to more severe reductions in sugar and phenol accumulation, and even altering the varietal and regional typicity of the grapes. Furthermore, drought and heat waves can alter the timing of ripening, leading to a shift in the balance of the different classes of phenolic compounds. For example, flavonoids tend to accumulate earlier in the ripening process, while non-flavonoid phenolic compounds, such as hydroxycinnamic acids, accumulate later. This shift in the balance of phenolic compounds can impact wine quality, altering the wine's color, aroma, and flavor profiles.

3. Yield and berry composition observations during harvest 2023 in southern Uruguay

Measurements conducted at two vineyards in the southern region of Uruguay, the country's primary wine-growing area, revealed a decline in yield for certain grape varieties. Specifically, a yield reduction ranging from 8% to 12% was observed for Tannat compared to the average of the preceding three harvests. Depending on the location, this decrease translated into a loss of between 1200 and 1580 kg of grapes. In the case of Merlot, a significant decline of 40% in yield was recorded, resulting in a loss of 4000 kg of grapes. Conversely, Albariño appeared to be less sensitive to environmental conditions, as no variations in yield were detected in the second year of the study. However, no definitive conclusions can be drawn as yet. The measurements also showed a decrease in berry size, with Tannat and Merlot experiencing a reduction of 0.5 g and 0.24 g, respectively.

Regarding primary composition, our observations showed a rise in sugar concentration for both Tannat and Merlot. Tannat exhibited a more substantial increase of 1.7º in probable alcohol, whereas Merlot had a slightly lower increase of 1.2º in probable alcohol.

The observations of a decline in yield, coupled with the increase in sugar concentration in Tannat and Merlot, can have significant implications for the wine production industry in Uruguay. A decrease in yield means less grape production, which can impact the availability and the price of wines made from these grape varieties. Additionally, the increase in sugar concentration can affect the final wine quality, leading to higher alcohol content and affecting the wine's balance of flavours and aromas.

4. High temperatures and drought effects on the composition of wine

Sugar concentration, acidity, availability of nutrients and growth factors, and the content of phenolic compounds in grapes play a fundamental role in the quality of the wine. High temperatures and drought affect the composition of the grapes, having consequences on the composition of the wine.

1- Wines with high alcohol content

Harvesting grapes with high sugar concentrations can cause problems during winemaking. First, an excess of sugars will determine a high production of alcohol, which can cause the slowing-down and/or the stop of alcoholic fermentation, since yeasts are exposed to the stress of the accumulation of high contents of ethanol and other toxic substances[8]. There is also a synergism between ethanol-sugar, and ethanol-metabolic derivatives, which can increase inhibition in fermentation[9] and lead to the formation of other metabolites such as acetic acid, increasing the volatile acidity of the wine. Secondly, the nutritional needs, particularly for nitrogen, are accentuated when the concentrations of grape sugars are high. It takes more generations

of yeasts to consume all the sugars so the demand for nitrogen is greater. Nutritional deficiencies cause generations of ethanol-sensitive yeasts that can slow or stop alcoholic fermentation. In addition, at the end of fermentation, the yeast population is at the limit of survival, in a very alcoholic environment, which, if it lacks the necessary nitrogenous resources, cannot carry out its work until the end. To mitigate these effects, it is important to use yeasts that are tolerant to the stress caused by the increase in sugars in grapes due to ripening conditions[10], and make external and fractionated nutritional supplements, considering the contribution of the different nitrogenous sources available on the market.

Alcohol also has an impact on the sensory characteristics of wine, particularly on the perception of aroma. While it increases the solubility of odorants in water and decreases their vapor pressure, it also contributes to the evaporation of other volatile odoriferous compounds[11].

Finally, the implementation of public policies and consumer health awareness has led to a decrease in the consumption of beverages with high levels of alcohol. Although moderate consumption of red wine can have beneficial health effects due to its significant content of bioactive compounds, wine contains important alcohol values.

2- Wines with high pH

High temperatures and drought during ripening can determine that the grapes present low acidity and high pH at harvest. In addition, the extraction of cations, mainly potassium, during maceration contributes to neutralize part of the tartaric acid, which results in a decrease in the titratable acidity and an increase in the pH of the wines. In wines with high pH, the antiseptic and antioxidant effectiveness of sulfur anhydride is lower, and the susceptibility to the development of unwanted microorganisms and oxidation increases[12]. The increase in the pH of the wines determines a decrease in the intensity of the color, due to the displacement of the balance of anthocyanins towards colorless forms. In these conditions, it is essential to correct the pH of the wine, which results in an increase in production costs.

3- Difficulty in defining the harvest

To produce full-bodied wines with intense color, it is necessary to harvest the grapes in an advanced state of maturation and carry out an intense extraction of the phenolic compounds during winemaking. Grape pulp usually ripens faster than skins and seeds, and results in high pH and sugar concentrations in the must[13]. This effect is accentuated when high temperatures and drought occur during the ripening of grapes. Under these circumstances, winemakers can choose between two options to define harvest. On the one hand, they can harvest grapes with adequate sugar content and pH but inadequate skin and seed maturation, which will probably result in poorly colored, bitter, astringent, and herbaceous wines. On the other hand, they can wait for complete phenolic maturity and assume that will lead to grapes with very high pH and sugar content[14]. In both cases, risks are assumed that must be worked during winemaking if the objective is to produce a quality wine.

5. Alternatives to mitigate the impact of high temperatures and drought on wine composition

An alternative winemaking management to reduce the alcohol content and pH of the wine, without affecting its color and phenolic composition, is the partial substitution of the must from the ripe grape with the immature grape must of the cultivar itself. The sugars and acids, which determine the alcohol content and pH of the wines, are in the pulp of the grape, while the phenolic compounds responsible for the color and body of the wine are in the skins. Thus, it is possible to macerate the skins and seeds of the ripe grape in a must partially substituted by immature grape must, with a lower concentration of sugars and higher total acidity. This alternative has the disadvantage that the immature grape must be kept at a low temperature until its use, so the winery must have cold equipment sized for this purpose. An evaluated alternative is the use of

Ugniblanc grape musts to perform the substitution. Ugniblanc is the main white cultivar grown in Uruguay, very productive, which grapes have low concentrations of sugars with high titratable acidity in harvest, and which harvest coincides with the harvest of the main red varieties of the country. Both techniques have been evaluated on different cultivars and in different harvests. The results obtained in Tannat and Merlot wines show that the techniques are promising to reduce the ethanol content and pH of wines, without affecting their color or phenolic composition, in years where climatic conditions allow an over-ripening of the grapes.

Supplementary materials

Presentation (pdf)

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