Sustaining wine identity through intra-varietal diversification

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Keywords: Grapevine, Adaptation, Climate change, Clonal variability, Diversity

Abstract

To sustain wine identity in uncertain climate outcomes, the study of intra-varietal diversity is important to reflect the adaptive and evolutionary potential of current cultivated varieties. The aim of this ongoing study is to understand to what extent can intra-varietal diversity be a climate change adaptation solution. With a focus on early to moderate late ripening varieties, data was collected for flowering and veraison for the various studied accessions and clones. For phenological growing stages, heat requirements were established using nearby weather stations and model performances were verified. Climate change projections were then integrated to predict the future behaviour of the intra-varietal diversity. Study findings highlight the strong phenotypic diversity of studied varieties and the importance of diversification to enhance climate change resilience. While model performances still require improvements, this study is the first step towards quantifying heat requirements of different clones and how they can provide adaptation solutions for winegrowers to sustain local wine identity in a global changing climate.

Introduction

Cultivated and shaped by human uses for many centuries, the grapevine has a rich genetic diversity with an estimated five to ten thousand varieties worldwide. Each variety has a climate suitability range, explaining the ecological fitness of varieties to a set of environmental conditions (Neethling et al., 2019). Climate change is questioning these climate niches, especially the upper suitability range for traditional varieties (van Leeuwen et al., 2019). With warmer temperatures, berry ripening is reached too soon, causing grapes to be rich in sugars, low in acidity, giving place to unbalanced wines that lack in aromatic complexity. To maintain a premium in the global market by ensuring high quality wines, winegrowers can draw on the diversity among grapevines to limit expected climate change impacts, by selecting more heat and drought tolerant varieties (Morales-Castilla et al., 2020).

However, replacing a traditional variety that has created a sense of territorial distinctiveness may cause additional socio-economic and ecological challenges, leading to rebounding vulnerability. While product authenticity from a sensory perspective has and continue to evolve, the economic concern can be the consumers' willingness to pay for new products or even the willingness to accept if they are familiar with the former product identity. This degree of acceptance is also an issue for winegrowers, who pass on from generation to generation a form of cultural heritage and constructed knowledge on growing sustainably grapes and producing quality wine from traditional varieties.

Despite ongoing projects on genetic diversity among grapevine and rootstocks varieties for climate change adaptation (van Leeuwen et al., 2019), the study of intra-varietal diversity is important to reflect the adaptive and evolutionary potential of current cultivated varieties. To sustain wine identity in uncertain climate outcomes, the aim of this ongoing study is to understand to what extent can intra-varietal diversity be a climate change adaptation solution.

Materials and methods

With a focus on early to moderate late ripening varieties, historical data was collected for agronomy observations of flowering (BBCH 65) and veraison (BBCH 81) for the various studied accessions (from the regional repository plots) and clones (Table 1). At the same time, meteorological data from the closest weather station were compiled from the different sites. For each weather station, the daily minimum and maximum temperatures were used to calculate daily average temperatures.
For these two phenological growing stages, heat requirements were then established using the daily average temperatures recorded by nearby weather stations. The Grapevine Flowering Veraison model (Parker et al., 2013) was applied to simulate the heat units necessary to reach a specific phenological stage for each individual clone. Heat accumulation was based on a daily temperature threshold of 0°C and the starting day for the thermal summation fixed at the 60th day of the year.
Once the quality of the phenology model was evaluated by calculating the root mean squared error (RMSE) between simulated and observed phenology data, climate change projections (RCP2.6, 4.5, 8.5) from 2011 to 2100 were integrated to predict the future behaviour of the intra-varietal diversity. Climate simulations were acquired within the framework of the DRIAS project, which has a spatial resolution of 8 km over France after the model outputs were bias corrected by a quantile-quantile method. The goal was to observe for each variety how the individual clones are adapting to continuous regional warming and to understand the ecological suitability of the studied varieties when considering its genetic diversity.

Table 1. Data description of the studied accessions and clones of different varieties in the Loire Valley, Bordeaux and Alsace.

Region	Variety	Plot type	Population	Site	Years
Loire Valley	Chenin	Regional repository	187 accessions	Montreuil-Bellay	97-99
		Clonal study	15 clones	Montreuil-Bellay	09-11
		Clonal study	12 clones	Beaulieu/Layon	09-11
		Clonal study	12 clones	Cléré/Layon	09-11
	Sauvignon blanc	Regional repository	113 accessions	Montreuil-Bellay	97-02
		Regional repository	150 accessions	Montreuil-Bellay	14-15
	Grolleau noir	Regional repository	207 accessions	Montreuil-Bellay	00-03
		Clonal study	8 clones	Montreuil-Bellay	14-17
	Cabernet franc	Clonal study	15 clones	Montreuil-Bellay	09-11
Bordeaux	Petit Verdot	Regional repository	87 accessions	Mérignac	15-16
	Cabernet franc	Clonal study	15-20 clones	Saint-Émilion	09-16
Alsace	Pinot noir	Regional repository	422 accessions	Bergheim	86-93
	Riesling	Regional repository	433 accessions	Rorschwihr	82-91

Results and discussion

Study results showed a strong phenotypic variability within the same variety and how they translate into distinct heat requirements. For example, Table 2 illustrate the calculations on historical data for Chenin and Sauvignon blanc in the Loire Valley. Chenin clones with an early onset in flowering required 1301 heat units, compared to almost 1400 heat units for clones with a delayed phenology. Whereas Sauvignon blanc clones with an early flowering required 1352 heat units, compared to 1422 heat units for clones with a late flowering date. Like the observations made by Parker et al. (2013), these variations in phenology and heat requirements between individual clones become more important over the growing season as shown for the onset of berry ripening (i.e. veraison). For example, Chenin clones with an early veraison required 2618 heat units, compared to almost 2900 heat units for clones with a delayed phenology. Whereas Sauvignon blanc clones with an early onset in flowering required 2480 heat units, compared to 2736 heat units for clones with a delayed veraison timing.
When considering the heat requirements for flowering and veraison displayed by Parker et al. (2013), Chenin as a variety requires 1280 heat units for flowering and 2712 units for veraison. Therefore, these values are close to the behaviour of early ripening clones according to study findings, displaying the interest to better understand the genetic diversity within the same variety. A similar result is observed for Sauvignon blanc, which requires in general 1282 heat units for flowering and 2528 units for veraison, therefore located in the early behavioural

range of clones studied in the Loire Valley. Most clones were selected in the second half of the 20th century, when early phenology was considered being an asset to achieve full ripeness. As a result, few late ripening clones are currently commercially available. This is confirmed in this study by the fact that temperature requirements published by Parker et al. (2013) are close to the earliest clones considered here. Hence, there is room for selecting clones with delayed phenology, which are better adapted to warmer climatic conditions.

Table 2. Average day of the year (DOY) and heat requirements for individual clones of Chenin and of Sauvignon blanc to reach the phenological stages of flowering and veraison. The data used for these initial calculations are historical records in Montreuil-Bellay, Loire Valley

Grapevine variety	Clone Range	Flowering DOY	Heat requirements for flowering	Veraison DOY	Heat requirements for veraison
Chenin blanc	Early	161	1301	228	2618
	Mean	164	1343	235	2771
	Late	168	1396	241	2895
Sauvignon blanc	Early	165	1352	225	2480
	Mean	167	1394	231	2660
	Late	169	1422	234	2736

According to the prediction model obtained from the phenotypic variation within studied grapevine varieties and clones, the ecoclimatic modelling approach seeks to understand the adaptive potential of such genetic diversity in a changing climate. Considering the example of the various clones of Chenin blanc to reach flowering, initial findings show that in the recent past (1971-2000), the flowering date was around 25 June (day 175) with a range of 6 days between the earliest and latest clones. According to the emission scenarios RCP2.6, 4.5 and 8.5, clones will advance between 7 and 8 days in the near future (2021-2050) with a range of 5 days between the earliest and latest clones. Except for the RCP2.6 scenario, a more substantial shift in flowering timing is expected in the far future (2071-2100) with the expected impacts of the 4.5 and 8.5 RCP climate scenarios (Figure 1). The range between the early and late clones remain 5 days.

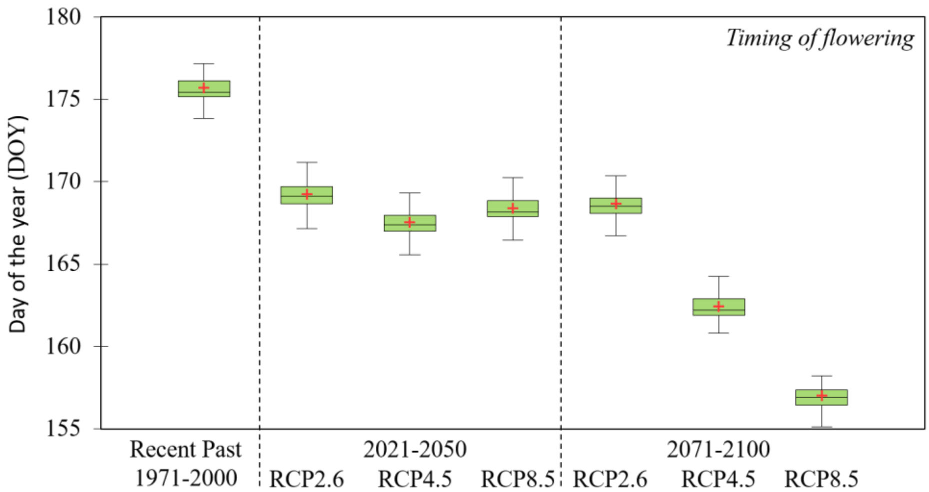

Figure 1. Box plots representing the temporal variability in flowering timing for Chenin blanc clones in the recent past and based on different climate scenarios for the near and far future. The range for box plots indicates the difference between the earliest and latest developing clone.

For the timing of veraison, similar results are obtained. Considering the example of the various clones of Chenin blanc to reach veraison, initial findings show that in the recent past (1971-2000), the timing of veraison was around 8 September (day 251) with a range of 15 days between the earliest and latest clones. According to the emission scenarios RCP2.6, 4.5 and 8.5, clones will advance between 11 and 13 days in the near future (2021-2050) with a range of 13 days between the earliest and latest clones. In the far future (2071-2100), veraison will advance by 22 days (RCP4.5) and by 32 days (RCP8.5) compared to 1971-2000. In both scenarios, the range between the early and late clones will be 11 days (Figure 2).

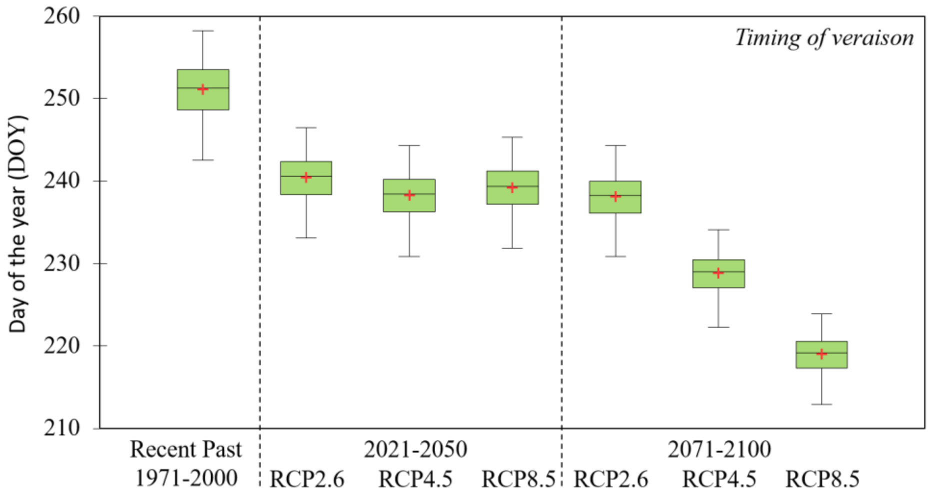

Figure 2. Box plots representing the temporal variability in veraison timing for Chenin blanc clones in the recent past and based on different climate scenarios for the near and far future. The range for box plots indicates the difference between the earliest and latest developing clone.

Conclusion

With the common objective to strengthen the resilience of the wine sector to climate change, the aim of this ongoing study was to understand to what extent can intra-varietal diversity be a climate change adaptation solution. Faced also with great uncertainty regarding future climate outcomes, intra-varietal diversification is also a rational and cost-effective strategy, esteemed as a no-regret option allowing winegrowers more certainty about future climate changes. Data was collected for flowering and veraison timing for the various accessions and clones of studied grapevine varieties. Study findings highlight the strong phenotypic diversity of studied varieties and the importance of diversification to enhance climate change resilience. While model performances still require much improvements, this study is the first step towards quantifying heat requirements of different clones and how they can provide adaptation solutions for winegrowers to sustain local wine identity in a global changing climate. As genetic diversity is an ongoing process through point mutations and epigenetic adaptations, perspective work is to explore clonal data from a wide variety of geographic locations.

Acknowledgments

This study was carried out with the contribution of the LACCAVE-INRAE research programme. We also thank the agricultural engineer and MSc Vintage students of the Ecole Supérieure d'Agricultures for their helpful contribution to this ongoing study.

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