

# Adaptability of grapevines to climate change: characterization of phenology and sugar accumulation of a large range of grape varieties, under hot climate conditions.

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## Abstract

Climate is the major factor influencing the dynamics of the vegetative cycle and can determine the timing of phenological periods. Knowledge about varieties' phenology, their chronological duration, and thermal requirements, allows not only the better management of interventions in the vineyard, but also to predict varieties' behaviour under a scenario of climate change, giving the wine producer the possibility of selecting the varieties that are best adapted to the climatic conditions of a certain terroir. In 2014, Symington Family Estates established two grape variety libraries in two different places with distinctive climate conditions, with the commitment of contributing to a deeper agronomic and oenological understanding of some grape varieties, in hot climate conditions. Since 2017, phenological observations have been made to determine the average dates of budbreak, flowering and véraison, the thermal requirements and the chronological duration of each phase have been also calculated. During maturation, berry samples have been collected to study the dynamics of sugar accumulation. The data was analysed applying phenological and sugar accumulation models available in literature. The results obtained show significant differences between the varieties over several parameters, between the two locations, confirming the influence of climate on phenology and maturation, in these specific conditions.

## Introduction

The climate conditions play a relevant role in vine's growth (Jones *et al.*, 2005; Lopes *et al.*, 2008; Alves *et al.*, 2013) and temperature is one of the major factors interfering in grapevine's development. (Parker *et al.*, 2011, Malheiro *et al.*, 2013; Parker *et al.*, 2013) The expected rise of temperature caused by climate change can lead to phenology advance and jeopardize the viability of high-quality grapes production, in some wine regions. (Jones *et al.*, 2005; Fraga *et al.*, 2012) To counteract this trend and adapt varieties to future climatic conditions is important to know the thermal requirements to complete the main phenological stages and reach a desired target sugar concentration value. (Parker *et al.*, 2020a)

The aim of this work is to study the influence of climate in a wide range of varieties. The mid-date occurrence for budbreak, flowering (both not showed in this work) and veraison was determined for the cultivars present in two Grape Varieties Libraries. To evaluate the dynamic of sugar accumulation, the day of the year (DOY) when a target value of sugar was reached was determined.

## Materials and methods

This study was conducted at Symington's Grape Variety Libraries, located at Quinta do Bomfim (41.189245, -7.540943, sub-region Cima Corgo) and Quinta do Ataíde (41.248395, -7.111794, sub-region Douro Superior), Douro region, Portugal. The vineyards were planted in 2014, with the aim of study the oenological and viticultural potential, preserve less known cultivars and study the varieties' adaptability to climatic conditions. At Ataíde are planted 53 varieties, with 200 plants per grape variety, grafted in 196-17 rootstock. The vines are pruned in Royat single cordon, vertical shoot positioned trellis, with ca 8 to 10 buds per vine. The second grape library is smaller than the previous one, with 29 grape varieties, grafted in 196-17 rootstock. The number of

plants per cultivar varies from 25 to 75 plants and the vines are pruned in Royat single cordon, vertical shoot positioned and have around 8-10 buds per plant.

The climate in both locations is summarized on table 1. Data from the five years study display the most important differences in the two environments. At Quinta do Ataíde we get less annual and growing season precipitation, with lower temperature during winter and spring, and a summer warmer than Quinta do Bomfim, with influence on ripening dynamic. The heat accumulation (Growing Degree Days) is quite similar in both locations, but with different speeds on the accumulation, lower at beginning of the cycle in Quinta do Ataíde, and faster in late season, from veraison to harvest time.

**Table 1.** Climate conditions at Quinta do Bomfim and Quinta do Ataíde from 2017 to 2021. Viticultural year from November to October. Growing season from April to October.

	Year	Prec.	Prec. GS	Tmed	Tmed GS	T>30°C	T>35°C	T>35°C	ETp	ETp	GDD*	GDD*	
		Nov-Oct (mm)	Apr-Oct (mm)	Nov-Oct (°C)	Apr-Oct (°C)	Apr-Oct (days)	Apr-Oct (days)	Jun-Jul-Aug (days)	(%)	Nov-Oct (mm)	Apr-Oct (mm)	Jan-Oct (°Day)	Apr-Oct (°Day)
Bomfim	2017	316,2	86,6	16,9	22,0	112	38	34	36%	1208	1108	2810	2643
	2018	671,0	274,4	16,0	20,9	96	36	26	27%	1136	939	2515	2440
	2019	485,6	197,6	16,2	20,5	87	27	23	24%	1154	939	2495	2336
	2020	576,4	216,2	17,0	21,1	87	48	39	41%	1160	950	2669	2453
	2021	530,0	223,6	16,3	20,3	70	23	22	23%	1095	909	2504	2306
	Average (5 years)	<b>515,8</b>	<b>199,7</b>	<b>16,5</b>	<b>21,0</b>	<b>90</b>	<b>34</b>	<b>29</b>	<b>30%</b>	<b>1150</b>	<b>969</b>	<b>2599</b>	<b>2435</b>
Ataíde	2017	314,6	80,8	16,7	22,1	128	58	49	53%	1167	1075	2743	2596
	2018	543,8	218,2	15,7	20,8	109	41	32	35%	1139	938	2425	2359
	2019	356,6	170,0	15,8	20,5	100	40	36	39%	1198	976	2369	2257
	2020	512,6	200,0	16,7	21,3	100	56	47	51%	1215	1001	2602	2429
	2021	504,4	256,2	15,9	20,2	80	29	27	29%	1126	921	2411	2249
	Average (5 years)	<b>446,4</b>	<b>185,0</b>	<b>16,2</b>	<b>21,0</b>	<b>103</b>	<b>45</b>	<b>38</b>	<b>42%</b>	<b>1169</b>	<b>982</b>	<b>2510</b>	<b>2378</b>

\* Growing Degree Days ( $\Sigma > 10^{\circ}\text{C}$ )

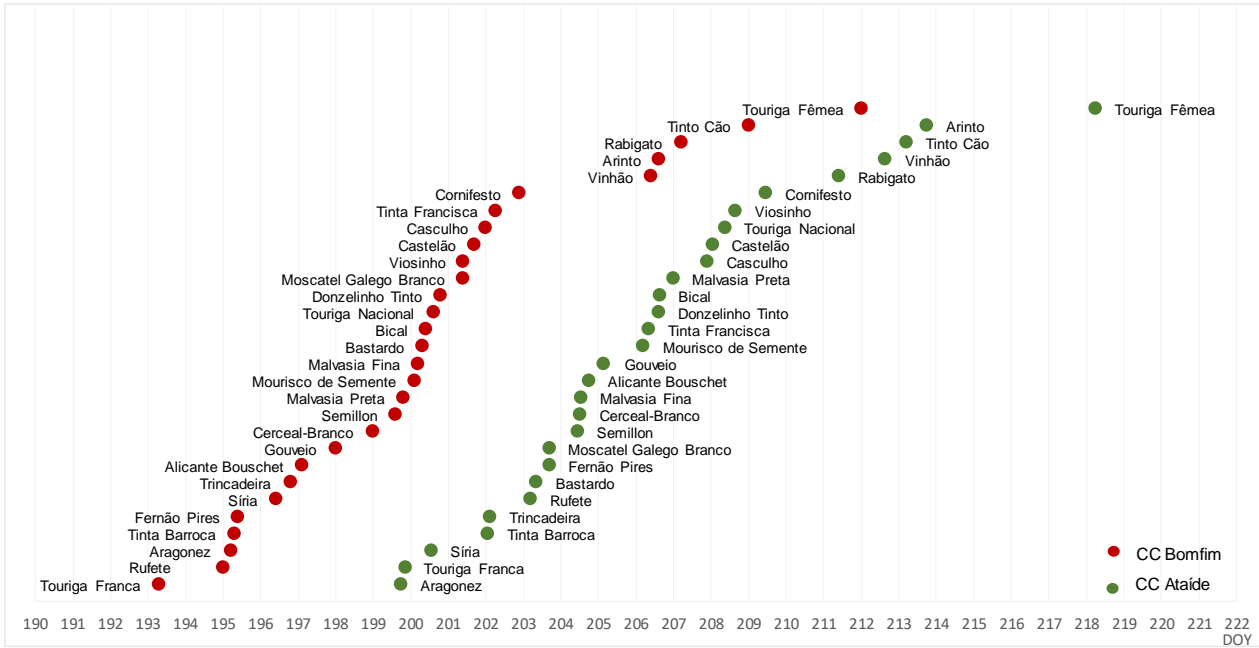
The phenological records have been done since 2017, following a strict protocol of observation, the same used in the *VitAdapt Project* (Destrac-Irvine & van Leeuwen, 2016). The observations are performed always three times per week at budbreak (stage C), flowering (stage I) and veraison (stage M), according to the Baggiolini scale, always in the same group of plants, with 2 to 4 repetitions per variety, depending on the place.

During the ripening, samples of 50 berries/block were collected weekly. The berry quality was analysed for several parameters with FTIR Oenofoss. To define a common target on sugar accumulation, we estimate by two-point linear interpolation the day of year when each variety reach a certain value of sugar concentration, following the protocols described in literature (Parker *et al.*, 2020). In this study only the results for Ataíde are presented and although we simulate the accumulation from 170 g/l to 230g/l, only the results for 200g/l of sugar concentration are shown on this work.

## Results and discussion

The figure 1 shows the mid-veraison average dates (day of the year) of 29 varieties common in both collections to different climatic conditions. The varieties show great variability among them, and we observe that budbreak, flowering and veraison occurs first at Bomfim than Ataíde, however, during the period from veraison to maturation, the development is faster at Ataíde, consequence of higher temperatures during the summer months. The amplitude of the intervals between the first and the last variety reaching 50% of budbreak at Bomfim are 12 days, to mid-flowering are 7 days and for mid-veraison 19 days. At Ataíde the range of values is similar: 13 days between the first and the last variety for mid-budbreak, 7 days mid-flowering and 18 days to mid-veraison. The figure 1 shows that the variation of days for reach 50% of veraison, for 29 varieties, in the two places, have a similar amplitude and a similar categorization for earlier, medium or late varieties, which indicates the genetic behaviour identical to these varieties under different climatic conditions.

We also have studied the maturation phase, to understand the climate influence not only in vines phenology but also grapes quality. In this paper we only present the results for Ataíde, including the 53 varieties.



**Figure 1.** Distribution of varieties according to mid-veraison date in Bomfim and Ataíde. Average of 5 years.

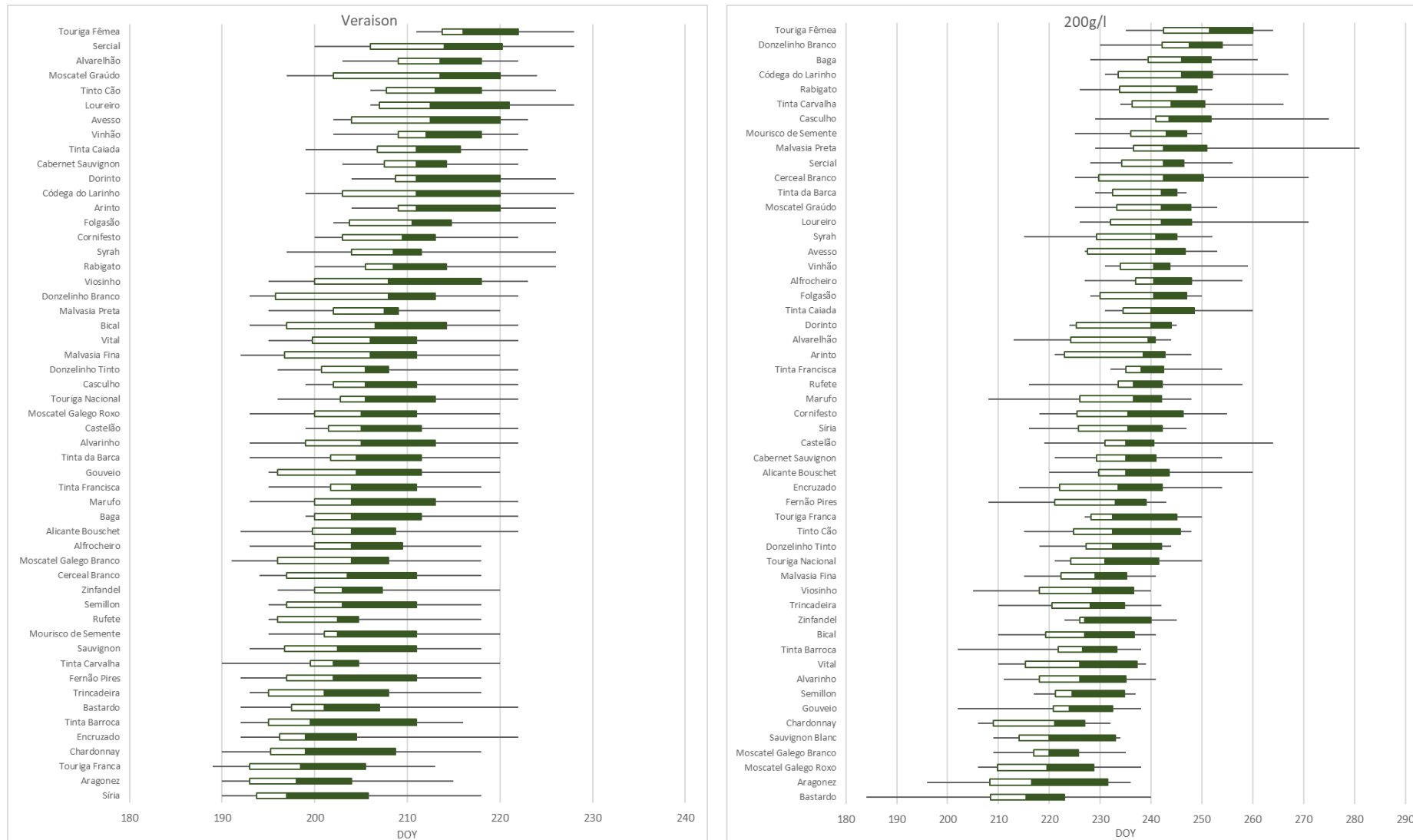
The figure 2 shows the mid-date veraison for 53 varieties, at Ataíde Grape Library and the day of the year (DOY) when each variety reach a target value of 200g/l of sugar. The values presented were obtained from an interpolation, considering the results of analysis done every week. The year of 2020 was very hot, with 47 days with maximum temperature above 35°C, and as it seems that high temperatures influence the sugar accumulation (Parker *et al.*, 2020b; Suter *et al.*, 2021), disturbing the rhythm of sugar accumulation and causing irregular maturation in some varieties, this year is not included in the results.

At Ataíde, the interval of days from the earliest variety to reach 50% of veraison from the latest is 19 days. When the interpolation is performed to determine the date when a certain variety reaches 200g/l of sugar accumulation, we see that the order between them changes, which evidences different maturation dynamics and the interval between the first and the last variety to reach the desired value is higher, 35 days on the 5 years average. This reveals a great variability between the cultivars and offers a wide potential of adaptation.

This collection of data will be useful to further works on modelling the dynamic of the phenology to future climatic scenarios, allowing the winegrower to select the most suitable varieties to face a scenario of climate change, prioritizing late-ripening varieties in places where is the temperature rise is expected. (Santos *et al.*, 2021)

## Conclusion

The present work represents a valuable tool to understand the climate influence in grape vine varieties phenology and maturation. Knowledge about those characteristics could be very useful to elect the most suitable variety to a determined *terroir*. We pretend to keep this project a few more years to obtain more data and build a strong and reliable phenology database, useful for future works, to apply models and simulate vine's response to climate change. Once our grape variety libraries have some cultivars in common with another experimental vineyards, where this kind of work is done, the data could be used to compare the interaction of genotype x environment, with the integration of different terroirs. To enrich this work, we are applying the same protocol, since 2020, in another experimental vineyard, exclusively dedicated to white varieties in common, locate a high elevation in the Region.



**Figure 2.** Classification of varieties by date of mid-veraison and sugar accumulation (target value 200g/l) for 53 varieties (Quinta do Ataíde, Douro Superior).

## References

- Alves, F., Edlmann, M., Costa, J., Costa, P., Macedo, P., Leal Da Costa, P., & Symington, C. (2013). Heat requirements and length of phenological stages. Effects of rootstock on red grape varieties at Douro region. 18<sup>th</sup> International Symposium GIESCO, Porto, Portugal, 7-11, July 2013., 5p.
- Destrac Irvine, A., and van Leeuwen, C. (2016). “The VitAdapt project: extensive phenotyping of a wide range of varieties in order to optimize the use of genetic diversity within the *Vitis vinifera* species as a tool for adaptation to a changing environment,” in Proceedings of the Sustainable Grape and Wine Production in the Context of Climate Change, Bordeaux, 165–171.
- Fraga, H., Malheiro, A.C., Moutinho-Pereira, J., Santos, J.A. (2012). An overview of climate change impacts on European viticulture. *Food Energy Secur.* 1(2):94–110. <https://doi.org/10.1002/fes3.14>
- Jones, V.G., White, M.A., Cooper, O.R. and Storchmann, K. (2005). Climate change and global wine quality. *Climatic Change*, 73: 319–343. <https://doi.org/10.1007/s10584-005-4704-2>
- Lopes, J; Eiras-Dias, J.E; Abreu, F; Clímaco, P; Cunha, J.P; Silvestre, J. (2008). Exigências térmicas, duração e precocidade de estados fenológicos de castas da Coleção Ampelográfica Nacional. *Ciência Téc. Vitiv.* 23 (1) 61-71.
- Malheiro, A.C., Campos, R., Fraga, H., Eiras-Dias, J., Silvestre, J., Santos, J.A. (2013). Winegrape phenology and temperature relationships in the Lisbon Wine Region. *Portugal. J. Int. Sci. Vigne Vin* 47(4): 287–299. <https://doi.org/10.20870/oenone.2013.47.4.1558>
- Parker, A.; García de Cortazar, I.; van Leeuwen, C.; Chuine, I. (2011). General phenological model to characterise the timing of flowering and veraison of *Vitis vinifera* L. *Aust. J. Grape Wine Res.*, 17, 206–216. <https://doi.org/10.1111/j.1755-0238.2011.00140.x>
- Parker, A., García de Cortázar-Atauri, I., Chuine, I., Barbeau, G., Bois, B., Boursiquot, J.-M., Cahurel, J.-Y., Claverie, M., Dufourcq, T., Gény, L., Guimberteau, G., Hofmann, R.W., Jacquet, O., Lacombe, T., Monamy, C., Ojeda, H., Panigai, L., Payan, J.-C., Lovelle, B.R., Rouchaud, E., Schneider, C., Spring, J.-L., Storchi, P., Tomasi, D., Trambouze, W., Trought, M. and van Leeuwen, C. (2013). Classification of varieties for their timing of flowering and veraison using a modelling approach: a case study for the grapevine species *Vitis vinifera* L. *Agric For Meteorol.* 180: 249-264. <https://doi.org/10.1016/j.agrformet.2013.06.005>
- Parker, A.K., García de Cortázar-Atauri, I., Trought, M. C. T., Destrac, A., Agnew, R., Sturman, A. and van Leeuwen, C. (2020a). Adaptation to climate change by determining grapevine cultivar differences using temperature-based phenology models. *OENO One* 2020, 4, 955-974. <https://doi.org/10.20870/oenone.2020.54.4.3861>
- Parker, A.K., García de Cortázar-Atauri, I., Gény, L., Spring, J., Destrac, A., Schultz, H., Molitor, D., Lacombe, T., Graça, A., Monamy, C., Stoll, M., Storchi, P., Trought, M.C.T., Hofmann, R.W., van Leeuwen, C. (2020b). Temperature-based grapevine sugar ripeness modelling for a wide range of *Vitis vinifera* L. cultivars. *Agricultural and Forest Meteorology*, 285-286, 107902. <https://doi.org/10.1016/j.agrformet.2020.107902>
- Santos, J., Young, C., Fraga, H.; Malheiro, A., Moutinho-Pereira, J., Dinis, L-T, Correia, C., Moriondo, M., Bindi, M., Leolini, L., Dibari, C., Costafreda-Aumedes, S., Bartolini, N., Kartschall, T., Menz, C., Molitor, D., Junk, J., Beyer, M. and Schultz, H. (2021). Long-term adaptation of European viticulture to climate change: an overview from the H2020 Clim4Vitis action. *IVES Technical Reviews vine and wine.* <https://doi.org/10.20870/IVES-TR.2021.4644>
- Suter, B., Destrac Irvine, A., Gowdy, M., Dai, Z. & van Leeuwen, C. (2021). Adapting Wine Grape Ripening to Global Change Requires a Multi-Trait Approach. *Front. Plant Sci.*, 12:624867. <https://doi.org/10.3389/fpls.2021.624867>