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La Tour Carnet 2050: insights on phenology and Yield of a very large collection of varieties

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The introduction of new grape varieties to Bordeaux is one of the available levers to build up resilience to climate change. An ideal candidate for varietal diversification must fulfill different criteria, including, among others, later phenology and economically sustainable Yield. In order to identify potential candidates to be introduced in the varietal mix of the Bordeaux area, an experimental parcel called "The Bordeaux 2050 plot" was planted at Château La Tour Carnet in the Haut-Médoc (Cru Classé of the 1855 classification) with 90 different varieties in order to characterise multiple varietal traits. Phenology and yield data are presented here to assist growers in their planting decisions.

La Tour Carnet 2050: a unique field experiment in a production setting

The project La Tour Carnet 2050 started with 26 different red varieties planted in 2013. Since then, more and more varieties have been added to form a collection of over 90 different varieties today. This project covers two different parcels: the "Bas" plot containing the 26 first varieties planted in 2013 and the "Haut" plot containing the rest of the varieties. The two parcels are located in the same area, only separated by a small path. Each variety is planted in a unique row made of 150 vines for the Bas plot and 300 vines for the Haut plot. Although this design is not ideal for obtaining the most scientifically robust dataset, a considerable benefit is the ability to produce wines at a larger scale than classical micro-vinifications.

Characterisation of the timing of budburst of 69 different varieties

The phenological stages of all the varieties were assessed during two vintages (2022 and 2023), following the methodology described in Destrac-Irvine *et al.* (2019)[1]. For each phenological stage, field observations were carried out at least twice a week until the 50% point of a given stage was reached. Phenology data from 48 varieties was collected on the « Haut » plot (planted from 2014 to 2016) and 25 varieties on the « Bas » plot (all varieties planted in 2013). Plot Haut contained 4 sampling locations comprising 5 vines each. Plot Bas contained 20 sampling locations comprising 16 individual vines and 4 lots of 5 vines each. The sampling locations were at the same distance from the beginning of each row. In order to compare the results of both vintages, results are expressed in thermal time (degree days): summation of daily mean temperatures starting from 1st January with a base temperature of 0°C. The timing of phenology is highly dependent on the climatic conditions of the vintage. The warmer vintage 2023 was earlier for budburst and veraison compared to 2022. However, the relative classification of the varieties was globally conserved during the two years.

Varieties can be grouped according to significant differences in budburst dates, which are shown in different colours in Figure 1. The group of varieties with the earliest budburst of the study, potentially more exposed to spring frost, include three traditional Bordeaux varieties: Merlot, Cabernet franc and Petit Verdot. Meanwhile, Cabernet-Sauvignon, Cot (Malbec) and Carménère have later budburst dates and, as such, are less exposed to spring frost. Marselan and Touriga Nacional, two varieties authorised since 2019 in the varietal mix specified in the Bordeaux appellation regulations (with a maximum of 5% of the planted area) show similar results to Cabernet-Sauvignon, with a later budbreak than Merlot. Arinarnoa (a variety created by INRAE, France, in the 1950s, also authorised in Bordeaux since 2019) is an interesting option for plots with high frost risk, as it is a variety that has late budburst, very close to the two latest varieties: Vinhão and Mourvèdre. The plot Haut show a larger diversity of budburst dates due to varietal differences. More than 200 growing degree days separate the two extreme varieties (which correspond to around eight days difference: a large window for frost risk). It is interesting to note that most white varieties tend to be earlier in their budburst dates than red varieties.

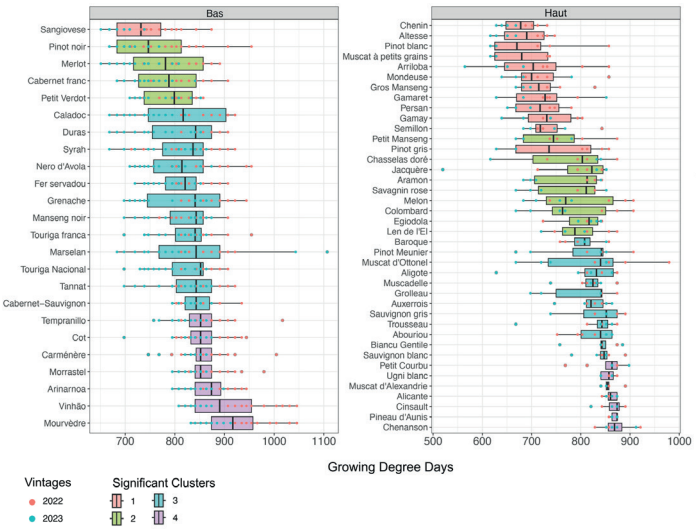


FIGURE 1. Budburst dates of the 69 varieties in 2022 and 2023 (expressed as growing degree days). Left panel shows the results from the "Bas" plot. Right panel shows the results from the "Haut" plot. Colours correspond to significantly different clusters as calculated with the k-means method.

Characterisation of the timing of veraison of 69 different varieties

Veraison date is another very relevant trait for the selection of climate change-adapted varieties. With climate change, the ripening period of varieties with earlier veraison occurs earlier in the season when temperatures are higher, which is not desirable. Varieties with later veraison push the ripening period to later in the season when temperatures are cooler. Hence, selecting late ripening varieties is an important lever for adaptation to climate change.

The classification of the varieties as a function of their veraison date (plotted here in degree days) does not follow the same pattern compared to budbreak dates (Figure 2). Indeed, some late budburst varieties can have an early veraison (for instance Cot (Malbec) or Touriga franca), while early varieties for budbreak can have

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later veraison dates (such as Cabernet franc). Petit Verdot has very particular behaviour: it is an early-budburst variety (inducing increased exposure to frost risk) but with the latest veraison date, making it well adapted to warm climates. Similar extreme behavior is observed for the two Mansengs (Petit and Gros), which have the latest veraison of the entire variety range (almost a month after the earliest varieties). These findings support the idea that varieties adapted to climate change conditions should be selected using a multi-trait approach. Each grower needs to identify her or his major criteria.

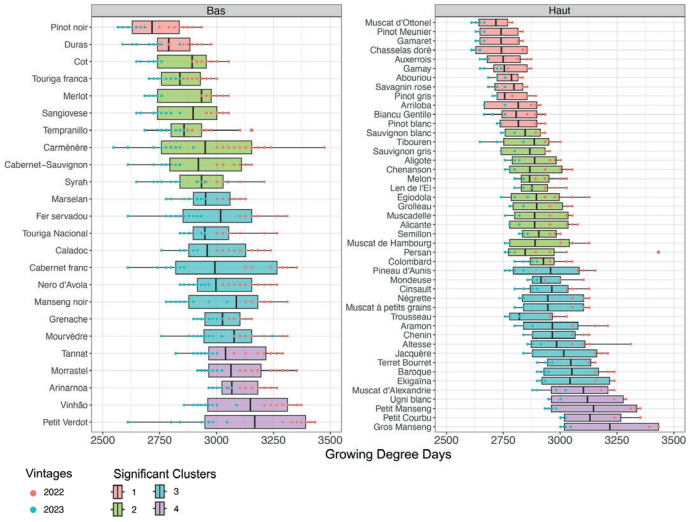


FIGURE 2. Veraison dates of the 69 varieties from 2022 and 2023 expressed as growing degree days. Left panel shows the results from the "Bas" plot. Right panel shows the results from the "Haut" plot . Colours correspond to significant different clusters as calculated with the k-means.

Interestingly, the order in which the varieties reach the veraison stage is comparable with another published study[2]: based on three vintages, Pinot noir was found to be the earliest in terms of veraison, while Petit Verdot and Arinarnoa were the latest of the varieties studied, which is in line with our findings. Similar results were obtained for Grenache, Tannat and Mourvèdre, which were rather late in reaching veraison (as in our study), and Cabernet-Sauvignon was in the mid-range with veraison dates close to Syrah (as in our study). Differences in behaviour were found for Tempranillo and Sangiovese, for which veraison was relatively late in Parker *et al.* (2020)[2], while they were found to be among the earliest varieties in our study.

Yield components of 26 red varieties

Yield components of all 26 varieties were assessed on the Bas plot in 2022 and for some of the varieties in 2023. Data were collected on the day of harvest from a pool of 10 to 17 vines randomly selected along the row. Yield components comprised average number of bunches per vine, average bunch weight and average berry weight. Yield components are highly dependent on climatic conditions, site and viticultural practices. Our study was conducted on a soil with a high proportion of clay and some gravel close to the surface. The vines were double-guyot pruned with 6 buds left on each vine and trained with vertical shoot positioning (VSP). The vines are dry-farmed and natural cover-crop is left in the middle of the row. The area under the vine row is tilled several times during the season to avoid excessive competition and no green harvest was implemented during the study. Local conditions and management practices clearly impact the final yield of the vines and thus the results of this study are site specific and cannot be easily transposed to other sites. However, it is likely that the hierarchy between high and low-yielding varieties is respected across different winegrowing regions.

Varieties with the lowest number of bunches per vine (Tempranillo, Nero d'Avola, Mourvèdre, Nielluccio, Morrastel) tend to have the highest bunch weight values (Figure 3). The exact opposite can be observed for some other varieties: Cabernet-Sauvignon and Vinhão have a high number of light bunches per vine. Bunch weight is highly driven by berry weight (Figure 3): varieties with lowest bunch weight also have the lowest berry weight (with the opposite also being true). The new varieties allowed in the Bordeaux appellation show contrasting behaviours. Arinarnoa tends to be a good compromise among the different varieties, with medium values for bunches per vine, medium values for bunch weight and medium values for berry weight. Touriga Nacional has a similar number of bunches per vine to Arinarnoa, but a higher berry weight and thus higher bunch weight. Similarly, Marselan has a high number of bunches per vine, but is characterised by low berry weight and thus lower bunch weight. Finally, Castets has an interesting set of yield components with a low number of bunches per vine, very low berry weight but medium bunch weight, because the Castets bunches have a high number of berries. However, only one year of data was collected on this variety and these findings need further confirmation.

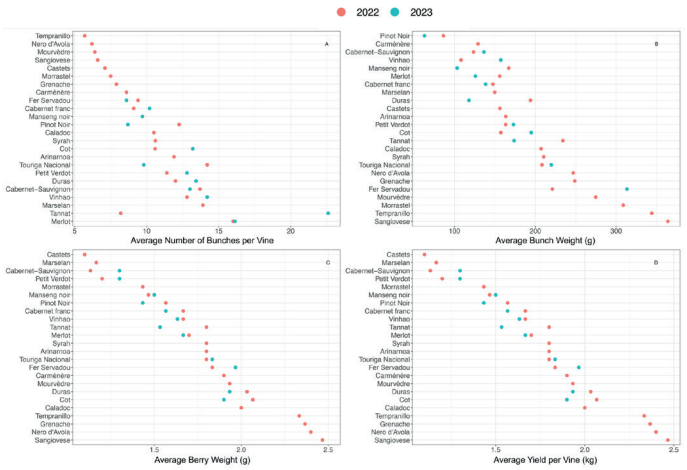


FIGURE 3. Yield components of the 25 varieties from the "Bas" plot. Panel A shows the average number of bunches per vine, panel B the average bunch weight, panel C the average berry weight and panel D the average yield per vine.

Conclusion

The aim of this research was to phenotype two important traits for varietal selection: phenology and Yield components, for a wide range of varieties in field conditions. The research focused particularly on 26 red varieties of potential interest in terms of adaptation to climate change in Bordeaux vineyards, as well as vineyards with comparable climatic conditions. Insights on the phenology of 48 other white and red varieties are also provided. These results allow to support decision making for varietal selection. Results were obtained under Bordeaux climatic conditions in a typical clay-gravel soil of the Haut-Médoc appellation and may differ under different pedo-climatic conditions. ■

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2 Parker, A. K., García de Cortázar-Atauri, I., Trought, M. C. T., Destrac, A., Agnew, R., Sturman, A., & van Leeuwen, C. (2020). Adaptation to climate change by determining grapevine cultivar differences using temperature-based phenology models. *OENO One, 54*(4), 955–974. https://doi.org/10.20870/oeno-one.2020.54.4.3861

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