IVES Technical Reviews vine & wine

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Grapevine Latent Bud Dormancy and Shoot Development

>>> Grapevine development comprises different phenological stages from bud break to berry maturation which are mainly temperature and water dependent. Pre bud break, there is a crucial stage called dormancy which can be divided in two periods: endodormancy and ecodormancy. Climate change (increase in average temperatures and drought) may accelerate the onset of bud burst, however with greater heterogeneity, thus increasing the risk of shoot exposure to abiotic and biotic constraints. Obviously, this could lead to yield and quality issues. In this regard, the ability to assess when climatic conditions are suitable for dormancy release and to predict the date of bud break is important. <<<

Grapevine latent bud dormancy

Grapevine dormancy is a crucial grapevine phenological period comprising of both endodormancy and ecodormancy[1]. This period prepares the development of the latent buds in spring to eventually undergo bud break. The latent buds bear the primordia of the future primary shoots and the primordia of the inflorescences, hence the future clusters (figure 1).

➔ Endodormancy

Endodormancy is the inhibition of growth originating from the latent bud meristem. It is brought about by internal factors within the plant, which prevent the breakage of dormancy even if external factors are optimal for growth. In grapevine these internal factors could be related to changes in the concentrations of primary and secondary metabolites, together with hormones such as abscisic acid (ABA). It is proposed that ABA maintains dormancy by repressing the bud meristem activity. In contrast, the application of chemicals such as hydrogen cyanamide or sodium azide promotes the release of dormancy[2] but some of these chemicals are not allowed in Europe, because of their high environmental impact.

Aside from hormonal regulation, endodormancy is triggered by shorter days and cooler temperatures. Winter chilling is then necessary to overcome endodormancy. Although the effect of chilling temperature on dormancy release needs further research at the molecular level, a 200 hours-period (eight days) with a mean daily temperature ≤ +8 °C proved to be efficient to permit the buds to break within a reasonable duration and to an acceptable level[3]. It would be logical that the chilling requirement is stable for a given cultivar, regardless if the cold period is interspersed with warm temperatures[4,5]. However, there are varietal differences in how much chilling is required[6].

Figure 2 demonstrates that from 1st December 2019 to 2nd February 2020, the required number of days (8 days) with a mean temperature of ≤ +8 °C has been reached to release the bud from endodormancy (South of France; data from L'Institut Agro-Montpellier SupAgro (IHEV) experimental vineyard weather station).

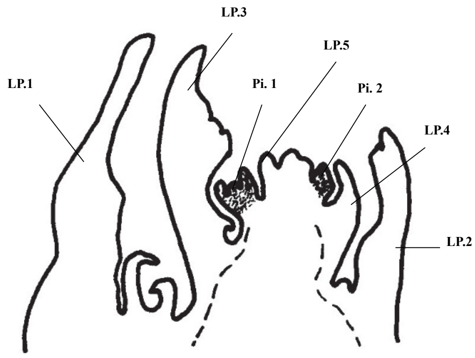

Figure 1. Longitudinal section of a latent bud showing the origins of the future primary shoot (from Carolus, 1970). Growth and differentiation of the latent bud stops in February (southern hemisphere) and in August (northern hemisphere). In this example, the primordium of inflorescence 1 is placed opposite the leaf primordium 4; the primordium of inflorescence 2 is placed opposite the leaf primordium 5. The future primary shoot will bear 2 clusters in position 4 and 5 from the bottom. LP: leaf primordium; Pi: primordium of inflorescence (from Carbonneau *et al.*, 2015).

➔ Ecodormancy

When endodormancy has been surpassed, grapevine cultivars are physiologically ready for bud break, however conditions that lead to ecodormancy must now also be overcome. Vines can exist within an ecodormant state if environmental factors that support root activity and bud growth are not optimal. These main environmental factors include temperature (air and soil) and water (soil water content). A few models have been developed to assess and forecast bud break[6, 7].
The dates of endodormancy and ecodormancy release in those models are predicted from chilling and forcing air temperature requirements only. Bud burst is predicted in the models when 50 % of buds have reached this particular stage (b, c, d) of figure 3). However, the models do not predict the duration of budburst from the onset to the maximum budburst rate, nor the maximum budburst rate and thus the shoot number.

Shoot development

After bud break, temperature continues to play a crucial role for primary shoot development from the preformed organs within the latent buds (figure 3). The number of unfolded leaves on individual main shoots can be predicted in the absence of environmental stress from the phyllochron (i.e. the Thermal Time between the development of two successive unfolded leaves or two phytomeres).
A total of ~+21 °C days is needed for a new unfolded leaf to be formed on the primary shoot. This is calculated using a base +10 °C, because +10 °C is the minimum required temperature for a vine to grow. For example, two consecutive days with an average temperature of +21 °C per day are enough to form a new unfolded leaf (i.e. one internode or phytomer)[8].

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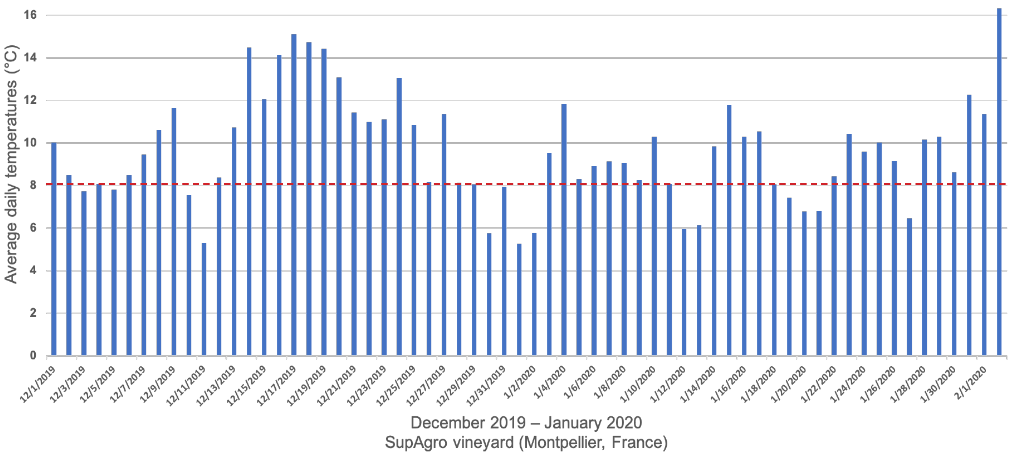

Figure 2. Example of average daily temperatures from 1st December 2019 to 02 February 2020: the number of days with an average daily temperature ≤ +8 °C was 11 days, which is enough to release the endodormancy (the red dot line is to indicate +8 °C).

■ Conclusion

Temperature can be used to predict the date of bud dormancy release (eco- and endodormancy) and primary shoot development. Cold winter temperatures (<+8 °C) are required for vines to be released from endodormancy. Then, warm temperatures (>+10 °C) are necessary for bud break and shoot development. However, most temperature-based models of budburst do not predict the duration and the rate of budburst which may induce exposure to environmental risks and which may impact on crop load. In addition, they do not consider other environmental factors (photoperiod, water and nutrient supply) and crop management (pruning rate and date, source to sink ratio) that also impact on the vine's ability to enter into dormancy, to begin growth from bud break onward and for the phytomers to develop (one phytomere = one node + one internode, bearing each one leaf and sometimes tendrils or clusters).

■ Further questions to be addressed in the context of climate change…

Most of the world's viticulture regions are located between latitudes of 40° and 50°N in the northern hemisphere and between latitudes of 30° and 40°S in the southern hemisphere, referred to as the temperate climatic belt. The evolution of the climate could be an issue regarding the need for cold temperature in winter to release the endodormancy. This could impact on:

➔ the number and the homogeneity of latent bud break and growth
➔ the latent bud fertility from bud break onwards
➔ the number of developed primary shoots and clusters per vine impacting on yield
➔ the dynamic of berry maturation increasing the heterogeneity of bunch ripeness and the associated wine quality

These recent issues observed in warm-hot wine regions (South Africa, Australia, South America…) need further observation and experimentation to find appropriate solutions, for example: the choice of the cultivars and rootstocks, the adaptation of cultural practices (irrigation, pruning dates…). ■

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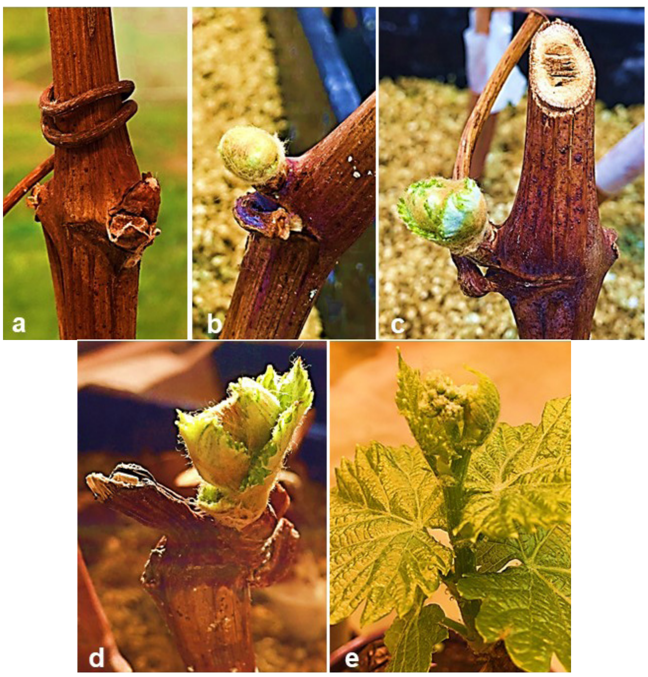

Figure 3. Example of grapevine latent bud (a) and latent bud burst stages (b, c, d) and example of shoot development (e).

1 Lang, G. A., Early, J. D., Martin, G. C., & Darnell, R. L. (1987). Endo-, para-, and ecodormancy: physiological terminology and classification for dormancy research. *HortScience*, 22(3), 371-377.
2 Pérez FJ, Vergara R, Or E., 2009. On the mechanism of dormancy release in grapevine buds: a comparative study between hydrogen cyanamide and sodium azide. *Plant Growth Regulation*, 59: 145–152.
3 Dokoozlian, N.K. 1999. Chilling Temperature and Duration Interact on the Budbreak of 'Perlette' Grapevine Cuttings. *Hortscience*, vol. 34(6), october.
4 Carbonneau A., Deloire A., Torregrosa L., Jaillard B., Pellegrino A., Métay A., Ojeda H., Lebon E., Abbal P., 2015. Traité de la Vigne, Physiologie, Terroir, Culture. Editions Dunod (2ème édition), pp573.
5 Anzanello R., Fialho F.B. and Santos H.P., 2018. Chilling requirements and dormancy evolution in grapevine buds. *Ciência e Agrotecnologia*, 42, 364–371.
6 Garcia de Cortazar Atauri I.G., Brisson N. and Gaudillere J.P., 2009 Performance of several models for predicting budburst date of grapevine (Vitis vinifera L.) *Int J Biometeorol*, 53:317–326, DOI 10.1007/s00484-009-0217-4.
7 Caffarra, A.; Eccel, E., 2010. Increasing the robustness of phenological models for *Vitis vinifera* cv. Chardonnay. *International Journal of Biometeorology*, 54 (3): 255-267. doi: 10.1007/s00484-009-0277-5 handle: http://hdl.handle.net/10449/19073.
8 Lebon, E., Pellegrino, A., Tardieu, F., and Lecoeur, J. (2004). Shoot development in grapevine (*Vitis vinifera L.*) is affected by the modular branching pattern of the stem and intra- and inter-shoot trophic competition. *Ann. Bot.*93, 263–274.doi: 10.1093/aob/mch038